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Inflation as a Global Phenomenon—Some Implications for Inflation Modelling and Forecasting*

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Abstract

We model local inflation dynamics using global inflation and domestic slack motivated by a novel interpretation of the implications of the workhorse open-economy New Keynesian model. We evaluate the performance of inflation forecasts based on the single-equation forecasting specification implied by the model, exploiting the spatial pattern of international linkages underpinning global inflation. We find that incorporating cross-country interactions yields significantly more accurate forecasts of local inflation for a diverse group of 14 advanced countries (including the U.S.) than either a simple autoregressive model or a standard closed-economy Phillips curve-based forecasting model. We argue that modelling the temporal dimension—but not the cross-country spillovers—of inflation does limit a model's explanatory power in-sample and its (pseudo) out-of-sample forecasting performance. Moreover, we also show that global inflation (without domestic slack) often contributes the most to achieve the gains on forecasting accuracy observed during our sample period (1984:Q1-2015:Q1)—this observation, according to theory, is crucially related to the flattening of the Phillips curve during this time period of increased globalization.

JEL codes: C21, C23, C53, F41, F62

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1 Introduction

"Forewarned, forearmed: to be prepared is half the victory!"

Don Quixote, by Miguel de Cervantes (1547-1616)

The New Keynesian model postulates that nominal rigidities lead to the non-neutrality of monetary policy in the short run and to an exploitable trade-off between inflation and aggregate economic activity—the Phillips curve relationship. Not surprisingly, Phillips curve-based forecasting models have featured prominently in policymaking as well as in the formation of public and private expectations about future inflation. Notwithstanding that, the empirical evidence on Phillips curve-based models continues to be an ongoing subject of debate among scholars and policymakers (Atkeson and Ohanian (2001), Stock and Watson (2007), Stock and Watson (2008), Kabukçuoğlu and Martínez-García (2016)).

Policymakers are mindful that the link between the domestic economic cycle and domestic inflation (the closed-economy Phillips curve) appears to have broken down. Yet, there is a growing recognition about the increasing role of global economic activity on domestic inflation and globalization's impact on policy (Fisher (2005), Fisher (2006), Bernanke (2007), Draghi (2015)). This has encouraged research on different aspects of the Phillips curve relationship from an open-economy perspective. European Central Bank (ECB) president Draghi (2015) recently summarized this viewpoint in the following terms:

> "Over the last decade there has been a growing interest in the concept of "global inflation." This is the notion that, in a globalised world, inflation is becoming less responsive to domestic economic conditions, and is instead increasingly determined by global factors."

In this paper, we argue that the open-economy New Keynesian framework is in general more suitable for forecasting and inflation modelling than its more conventional closed-economy variant. We note the potential for misspecification of closed-economy New Keynesian specifications arising from the increasing role of globalization—from greater integration through international trade—over the past decades. Hence, we take into account explicitly the international dimension linking the dynamics of local inflation to developments in the rest of the world. Our findings broadly confirm that an open-economy Phillips curve-based model often is more accurate than a naïve forecasting model that does not incorporate any cross-country linkages, and also more accurate than a closed-economy Phillips curve-based specification.

We build on a strand of the literature which argues that it is global slack—and not solely domestic slack—that impacts domestic inflation (Martínez-García and Wynne (2010), Martínez-García (2015), Kabukçuoğlu and Martínez-García (2016)). We show in theory that global inflation incorporates much of the same information about local inflation that global slack contains and, accordingly, is a useful predictor for inflation modelling and forecasting.

Next, we bring our theoretical insights to the data with a sample of 14 advanced countries (including the U.S.) to provide a broad empirical assessment of the open-economy New Keynesian model's implications for inflation modelling and forecasting. Our paper contributes to the international macro literature along several dimensions:

- We show that the weak performance and declining accuracy of closed-economy Phillips curve-based models of inflation forecasting during the Great Moderation (Atkeson and Ohanian (2001), Stock and

Watson (2008), Edge and Gürkaynak (2010)) can be partly attributed to misspecification—as closed-economy models ignore the growing importance of international linkages for domestic inflation.

- We note that limitations and data quality concerns on existing measures of global slack pose a challenge to exploit the open-economy Phillips curve relationship for inflation forecasting (Martínez-García and Wynne (2010)). Alternatively, we propose a novel structural approach consistent with the workhorse open-economy New Keynesian model that instead relies on information about global developments incorporated through global inflation. To be more precise, we show that global slack can be proxied by global inflation and domestic slack.
- We establish the theoretical basis for a parsimonious single-equation global-inflation-based forecasting model derived from the workhorse open-economy New Keynesian framework. We argue that this single-equation specification may indeed suffice to achieve an efficient forecast of domestic inflation without the need for a richer Bayesian VAR model (or a related multi-equation approach) containing foreign variables for forecasting inflation (Banbura et al. (2010), Duncan and Martínez-García (2015)).[1]
- We argue, at the same time, that global inflation alone is not a sufficient predictor for domestic inflation so one can potentially improve upon popular specifications found in the applied literature (Ciccarelli and Mojon (2010), Ferroni and Mojon (2014)) by incorporating a domestic slack proxy.
- Our paper shows that using a theoretically-consistent weighting scheme for aggregation to account for the relevant cross-country linkages in constructing global measures (global inflation and global slack) can be significant for improving the forecasting performance of the open-economy Phillips curve-based specification. In other words, an appropriately weighted global measure is all we would need to know about the interconnectedness of the economy with the rest of the world to help us forecast domestic inflation efficiently under the open-economy Phillips curve benchmark.
- We argue also that the sensitivity of inflation expectations to global inflation and domestic slack is invariant to the precise anti-inflation bias or even the tilt towards economic slack of the monetary policy rule, everything else equal. This is an important insight for policy evaluation that has not been fully recognized. It shows that a credible inflation-targeting central bank can alter the trade-off among their short-term policy goals—modifying its response to inflation deviations and slack within a Wicksellian-style Taylor (1993) rule—without inducing a change in the relationship between the expected path of inflation and its predictors (either global inflation and domestic slack or, alternatively, global slack).

Our empirical strategy is as follows: We conduct pseudo out-of-sample forecasts for a pair of inflation measures at horizons varying between 1-quarter to 12-quarters ahead. In particular, we use headline CPI and core CPI (all items ex. food and energy).[2] Our benchmark estimation and forecast periods are 1984:Q1-1996:Q4 and 1997:Q1-2015:Q1, respectively. We consider different weighting schemes for both inflation

[1] Duncan and Martínez-García (2015) in particular show how the cross-equation restrictions of the workhorse open-economy New Keynesian model lead to a restricted VAR specification and in related empirical analysis explore its forecasting performance. Our single-equation specification, in turn, relies on only a subset of the cross-equation restrictions implied by the model to produce this simpler forecasting model.

[2] The data sources are described in great detail in Grossman et al. (2014). Data availability varies across series. Hence, only a subset of up to 29 of the 40 countries covered in the database of Grossman et al. (2014) is included in each of our empirical evaluations. Details on which countries are included can be found in the Appendix.

and slack to account for international linkages and the "relative proximity" across countries—we use trade weights, bilateral geographical distance, population-weighted distance, contiguity, and equal weights.

The performance of our single-equation open-economy model specification is then compared against that of a naïve autoregressive model of inflation and against competing (nested) specifications including the closed-economy Phillips-curve-based one. Our metric to assess forecasting accuracy is the mean squared forecasting error (MSFE) of a given model relative to that of the nested autoregressive benchmark. We follow Clark and McCracken (2006) and Kabukçuoğlu and Martínez-García (2016) in order to calculate the critical values for the F-test statistic.

We conduct our forecasting comparison exercise across all forecasting models for 14 advanced countries (including the U.S.) and illustrate that our findings are largely robust on a wide range of country experiences. We show that our preferred specification of the open-economy Phillips curve model that uses global inflation and domestic slack helps generate more accurate predictions than (i) naïve forecasting models (autoregressive models), (ii) closed-economy Phillips-curve models, and (iii) open-economy Phillips-curve models based on standard (but possibly mismeasured) global slack indicators.

We also complement our forecasting evaluation exercise with an assessment of the in-sample fit of the open-economy Phillips curve model based on the mean squared error (MSE) and the Schwarz Information Criterion (SIC) over the full sample, which generally tends to validate the specification while reinforcing the finding that global inflation has played a dominant role during the Great Moderation until now. We argue that the main gains in forecasting accuracy arise empirically from adding global inflation as a predictor.

This finding on the predominance of global inflation is in part due to the fact that domestic slack (or related proxies) are not easily-measured as output potential is unobserved and model-dependent. But, most notably, we argue on the basis of theory that the contribution of global inflation can become dominant simply whenever the Phillips curve is flatter as this should result in a shift of the forecasting contributions away from domestic slack and towards the global factors captured by global inflation. This, in turn, partly relates our empirical results to existing work that highlights the flattening of the Phillips curve for the U.S. and many other countries during the Great Moderation (Roberts (2006)) at a time of increased globalization.

Hence, we conclude that our empirical and theoretical findings support the view that the Phillips curve is still alive and well for policy analysis, modelling, and forecasting—albeit through an open-economy lens.[3]

Related Literature. *Closed-Economy vs. Open-Economy Phillips Curve-Based Specifications.* The seminal work of Atkeson and Ohanian (2001) showed that closed-economy Phillips curve-based forecasts of U.S. inflation have become less accurate relative to those obtained from naïve specifications, judging by conventional metrics of forecasting accuracy such as the MSFE. An extensive survey by Stock and Watson (2008) suggests that Phillips curve-based forecasts and those of related models produce accurate forecasts only occasionally.[4] More structural approaches do not appear to improve the weak forecasting performance of the closed-economy Phillips curve relationship either (see Edge and Gürkaynak (2010) on this point).

In turn, our paper is grounded on the theoretical underpinnings of the open-economy New Keynesian

[3] A companion on-line Appendix with detailed derivations of the model and additional results can be found at: https://www.dallasfed.org/~/media/documents/institute/wpapers/2016/0261a.pdf.

[4] D'Agostino and Surico (2012) find that domestic money and output growth contribute to forecasting performance improvements (over naïve specifications) only marginally and often at times when the central bank has a low anti-inflationary bias and/or no clear nominal anchors.

model. It is worth noting that while the theoretical case for the open-economy Phillips curve is well understood, the empirical evidence remains somewhat mixed. On the one hand, Borio and Filardo (2007), Binyamini and Razin (2007), Martínez-García and Wynne (2010), Eickmeier and Pijnenburg (2013), Bianchi and Civelli (2015), and Kabukçuoğlu and Martínez-García (2016) are generally supportive of the predictions of the open-economy Phillips curve specification. On the other hand, Ball (2006), Pain et al. (2006), Ihrig et al. (2010), Milani (2010), and Milani (2012) find weaker evidence for the relationship.

This literature, in fact, suffers from severe problems related to inaccurate measures of global slack and other data limitations. These problems pose challenges in assessing the open-economy Phillips curve relationship and limit its practical use for policy analysis. In turn, our paper proposes a novel approach that is consistent with the open-economy Phillips curve and outperforms conventional forecasting models, including those that rely on global slack proxies. We find robust support across a variety of countries indicating that open-economy Phillips curve-based specifications can generate more accurate forecasts than those based on a naïve autoregressive or a closed-economy specification.

Global Inflation-Based Specifications. Our paper is closely related to a strand of the empirical literature that emphasizes the role of global inflation for forecasting inflation—and also provide a novel theoretical basis for it. Among others, Ciccarelli and Mojon (2010), Monacelli and Sala (2009), Mumtaz et al. (2011), Neely and Rapach (2011), and Mumtaz and Surico (2012) document the importance of the common component of inflation (global inflation) in the comovements of national inflation rates. Ciccarelli and Mojon (2010) and Ferroni and Mojon (2014) show encouraging results on the forecasting ability of global inflation for domestic inflation. Duncan and Martínez-García (2015) provide a related assessment of why domestic and global inflation tend to converge towards each other over time under a finite-order VAR representation of the workhorse open-economy New Keynesian model solution.

Our paper complements this body of work on the relationship between global and local inflation showing that a single-equation model specification—partly based on global inflation—is plausible. This single-equation specification can help overcome some of the data limitations plaguing the literature while it imposes fewer of the cross-equation restrictions that arise from the full-fledged open-economy New Keynesian model on the data itself. Our modelling contribution is both consistent with theory, parsimonious, and more flexible in its implementation. Moreover, while our paper provides a novel interpretation of why measures of global inflation contribute to improve forecasting accuracy, it also highlights at the same time that generally global inflation does not suffice to produce efficient forecasts of domestic inflation in the single-equation setting.[5] In that regard, we also show that adding domestic slack together with global inflation can theoretically suffice to achieve an efficient inflation forecast.

2 Inflation Modelling and Forecasting

We adopt the workhorse open-economy New Keynesian framework as our benchmark for inflation modelling (Martínez-García and Wynne (2010)). The model relates global developments to domestic inflation in a stylized two-country setting where goods are traded internationally. Both countries are symmetric, but with local-product bias in their respective consumption baskets.[6] The two countries produce equal shares

[5] Efficient forecasts in the sense that such forecasts cannot be improved with additional information.

[6] The share of Foreign (Home) goods in the Home (Foreign) consumption basket given by the parameter $0 \leq \xi \leq \frac{1}{2}$ determines the import share of each country in steady state and, therefore, their degree of trade openness.

of a mass one of varieties and are populated by the same fraction of a mass one of households.

Foreign variables are denoted with an asterisk (*). We express all variables, V_t, in logs as $v_t \equiv \ln(V_t)$. Then, $\widehat{v}_t \equiv \ln\left(\frac{V_t}{V}\right)$ denotes the log-deviation of the given variable V_t from its steady state, V. Similarly, $\widehat{\overline{v}}_t \equiv \ln\left(\frac{\overline{V}_t}{V}\right)$ denotes the log-deviation of such a variable from its steady state in the frictionless case that describes the potential (and natural rates) of the economy. As shown in Table 1, the Home and Foreign countries are characterized each by an open-economy New Keynesian Phillips curve (NKPC), an open-economy dynamic IS equation, and a Taylor (1993)-type interest rate rule for monetary policy. The model is, therefore, a straightforward extension of the standard three-equation (closed-economy) New Keynesian model to a two-country setting.

Monetary non-neutrality, which introduces a exploitable short-run policy trade-off between local inflation and the Home and Foreign output gaps, arises from monopolistic competition and producer currency pricing under staggered price-setting behavior à la Calvo (1983). Our model permits permanent shifts in the long-run inflation rate that align with the central bank's inflation target, while retaining the implication that the inflation process remains stationary around the deterministic zero-inflation steady state in the long-run.

Table 1 - Workhorse Open-Economy New Keynesian Model	
	Home Country
NKPC	$\widehat{\pi}_t - \widehat{\overline{\pi}}_t \approx \beta \mathbb{E}_t\left(\widehat{\pi}_{t+1} - \widehat{\overline{\pi}}_{t+1}\right) + \Phi(\varphi+\gamma)\left[\kappa \widehat{x}_t + (1-\kappa)\widehat{x}_t^*\right]$
Dynamic IS	$\gamma\left(\mathbb{E}_t\left[\widehat{x}_{t+1}\right] - \widehat{x}_t\right) \approx \Omega\left[\widehat{i}_t - \mathbb{E}_t\left[\widehat{\pi}_{t+1}\right] - \widehat{\overline{r}}_t\right] + (1-\Omega)\left[\widehat{i}_t^* - \mathbb{E}_t\left[\widehat{\pi}_{t+1}^*\right] - \widehat{\overline{r}}_t^*\right]$
Taylor rule	$\widehat{i}_t \approx \overline{\pi}_t + \psi_\pi\left(\widehat{\pi}_t - \overline{\pi}_t\right) + \psi_x \widehat{x}_t + \widehat{v}_t$
Natural interest rate	$\widehat{\overline{r}}_t \approx \gamma\left[\Theta\left(\mathbb{E}_t\left[\widehat{\overline{y}}_{t+1}\right] - \widehat{\overline{y}}_t\right) + (1-\Theta)\left(\mathbb{E}_t\left[\widehat{\overline{y}}_{t+1}^*\right] - \widehat{\overline{y}}_t^*\right)\right]$
Potential output	$\widehat{\overline{y}}_t \approx \left(\frac{1+\varphi}{\gamma+\varphi}\right)\left[\Lambda \widehat{a}_t + (1-\Lambda)\widehat{a}_t^*\right]$
	Foreign Country
NKPC	$\widehat{\pi}_t^* - \widehat{\overline{\pi}}_t^* \approx \beta \mathbb{E}_t\left(\widehat{\pi}_{t+1}^* - \widehat{\overline{\pi}}_{t+1}^*\right) + \Phi(\varphi+\gamma)\left[(1-\kappa)\widehat{x}_t + \kappa \widehat{x}_t^*\right]$
Dynamic IS	$\gamma\left(\mathbb{E}_t\left[\widehat{x}_{t+1}^*\right] - \widehat{x}_t^*\right) \approx (1-\Omega)\left[\widehat{i}_t - \mathbb{E}_t\left[\widehat{\pi}_{t+1}\right] - \widehat{\overline{r}}_t\right] + \Omega\left[\widehat{i}_t^* - \mathbb{E}_t\left[\widehat{\pi}_{t+1}^*\right] - \widehat{\overline{r}}_t^*\right]$
Taylor rule	$\widehat{i}_t^* \approx \overline{\pi}_t^* + \psi_\pi(\widehat{\pi}_t^* - \overline{\pi}_t^*) + \psi_x \widehat{x}_t^* + \widehat{v}_t^*$
Natural interest rate	$\widehat{\overline{r}}_t^* \approx \gamma\left[(1-\Theta)\left(\mathbb{E}_t\left[\widehat{\overline{y}}_{t+1}\right] - \widehat{\overline{y}}_t\right) + \Theta\left(\mathbb{E}_t\left[\widehat{\overline{y}}_{t+1}^*\right] - \widehat{\overline{y}}_t^*\right)\right]$
Potential output	$\widehat{\overline{y}}_t^* \approx \left(\frac{1+\varphi}{\gamma+\varphi}\right)\left[(1-\Lambda)\widehat{a}_t + \Lambda \widehat{a}_t^*\right]$
	Composite Parameters
	$\Phi \equiv \left(\frac{(1-\alpha)(1-\beta\alpha)}{\alpha}\right)$,
	$\kappa \equiv (1-\xi)\left[1 - (\sigma\gamma-1)\left(\frac{\gamma}{\varphi+\gamma}\right)\left(\frac{(2\xi)(1-2\xi)}{1+(\sigma\gamma-1)(2\xi)(2(1-\xi))}\right)\right]$,
	$\Theta \equiv (1-\xi)\left[\frac{\sigma\gamma-(\sigma\gamma-1)(1-2\xi)}{\sigma\gamma-(\sigma\gamma-1)(1-2\xi)^2}\right] = (1-\xi)\left[\frac{1+(\sigma\gamma-1)(2\xi)}{1+(\sigma\gamma-1)(2\xi)(2(1-\xi))}\right]$,
	$\Omega \equiv (1-\xi)\left(\frac{1-2\xi(1-\sigma\gamma)}{1-2\xi}\right)$,
	$\Lambda \equiv 1 + \frac{1}{2}\left[\frac{\left(\frac{\gamma}{\varphi+\gamma}\right)(\sigma\gamma-1)(2\xi)(2(1-\xi))}{1+\left(1-\frac{\gamma}{\varphi+\gamma}\right)(\sigma\gamma-1)(2\xi)(2(1-\xi))}\right]$.

An important takeaway from the open-economy model is that foreign slack—not just domestic slack—

plays a central role in modelling local inflation in deviations from its (time-varying) long-run rate. Domestic firms have some scope to pass domestic marginal cost fluctuations along to their domestic and foreign consumers through prices. However, unlike in the closed-economy New Keynesian environment, domestic marginal costs do not necessarily rise when the domestic economy starts to operate above potential and long-run inflation remains constant—if there is abundant foreign slack and the country is open to trade with the world. The key insight from the open-economy model is, therefore, that Home and Foreign slack are related to cost pressures at home and abroad and both should help us gauge domestic inflation.

The full system of equations presented in Table 1 pins down Home and Foreign inflation, $\widehat{\pi}_t$ and $\widehat{\pi}_t^*$, Home and Foreign output gaps (actual output minus the output potential under flexible prices and perfect competition), $\widehat{x}_t$ and $\widehat{x}_t^*$, and Home and Foreign short-term nominal interest rates, $\widehat{i}_t$ and $\widehat{i}_t^*$. In order to fully characterize the variables in this system of equations we also define the natural (real) rate of interest in each country that would prevail absent all frictions as $\widehat{\overline{r}}_t$ and $\widehat{\overline{r}}_t^*$, the long-run inflation rate as $\widehat{\overline{\pi}}_t$ and $\widehat{\overline{\pi}}_t^*$, and the corresponding central bank's inflation target as $\overline{\pi}_t$ and $\overline{\pi}_t^*$. Furthermore, we express the Home and Foreign monetary shocks as $\widehat{v}_t$ and $\widehat{v}_t^*$ respectively, and the aggregate productivity (TFP) shocks as $\widehat{a}_t$ and $\widehat{a}_t^*$.

The following deep structural parameters enter into the solution of the workhorse open-economy New Keynesian model: the intertemporal discount factor $0 < \beta < 1$, the inverse of the intertemporal elasticity of substitution $\gamma > 0$, the inverse of the Frisch elasticity of labor supply $\varphi > 0$, the Calvo (1983) price stickiness parameter $0 < \alpha < 1$, the degree of openness $0 \leq \xi \leq \frac{1}{2}$, and the (Armington) trade elasticity of substitution between domestic and imported goods $\sigma > 0$.

The Natural Rates and Productivity Shocks. Business cycle fluctuations in the model depend on the country-specific Home and Foreign TFP shocks, $\widehat{a}_t$ and $\widehat{a}_t^*$. TFP shocks follow a standard bivariate VAR(1) process allowing for cross-country spillovers and internationally-correlated innovations:

$$\begin{pmatrix} \widehat{a}_t \\ \widehat{a}_t^* \end{pmatrix} \approx \begin{pmatrix} \delta_a & \delta_{a,a^*} \\ \delta_{a,a^*} & \delta_a \end{pmatrix} \begin{pmatrix} \widehat{a}_{t-1} \\ \widehat{a}_{t-1}^* \end{pmatrix} + \begin{pmatrix} \widehat{\varepsilon}_t^a \\ \widehat{\varepsilon}_t^{a*} \end{pmatrix}, \quad \begin{pmatrix} \widehat{\varepsilon}_t^a \\ \widehat{\varepsilon}_t^{a*} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_a^2 & \rho_{a,a^*}\sigma_a^2 \\ \rho_{a,a^*}\sigma_a^2 & \sigma_a^2 \end{pmatrix} \right), \quad (1)$$

where the persistence of the TFP shock process depends on δ_a with cross-country productivity spillovers determined by δ_{a,a^*}. The volatility of the innovations is given by σ_a^2 and the cross-country correlation by ρ_{a,a^*}. Here, TFP shocks enter into the dynamics of the model only through their impact on the Home and Foreign natural (real) rates, $\widehat{\overline{r}}_t$ and $\widehat{\overline{r}}_t^*$, as indicated in Table 1. Therefore, their contribution over the business cycle depends on how sensitive the natural (real) rate is to expected TFP growth in both countries.[7] In particular, it critically depends on parameters influencing the bilateral trade relationship—the share of foreign goods in the local consumption basket, $0 \leq \xi \leq \frac{1}{2}$, and the trade elasticity of substitution between Home and Foreign goods, $\sigma > 0$—as well as on other deep structural parameters like the intertemporal elasticity of substitution, $\gamma > 0$, and the inverse of the Frisch elasticity of labor supply, $\varphi > 0$.

The Monetary Policy Rules and Monetary Policy Shocks. Each country's central bank responds to local conditions—to deviations of local inflation from target and to the country's own slack—as implied by the

[7] The relationship between natural rates and the TFP shock process can be expressed as follows:

$$\begin{pmatrix} \widehat{\overline{r}}_t \\ \widehat{\overline{r}}_t^* \end{pmatrix} = \gamma \left(\frac{1+\varphi}{\gamma+\varphi} \right) \begin{pmatrix} \Theta\Lambda + (1-\Theta)(1-\Lambda) & \Theta(1-\Lambda) + (1-\Theta)\Lambda \\ (1-\Theta)\Lambda + \Theta(1-\Lambda) & (1-\Theta)(1-\Lambda) + \Theta\Lambda \end{pmatrix} \begin{pmatrix} \mathbb{E}_t[\Delta\widehat{a}_{t+1}] \\ \mathbb{E}_t[\Delta\widehat{a}_{t+1}^*] \end{pmatrix}.$$

well-known Taylor (1993) rule for monetary policy. The policy weight on inflation deviations is given by the parameter $\psi_\pi > 0$ while the weight on slack is determined by $\psi_x > 0$. Central banks' adjust their policy rates to track changes in their country's natural (real) rate of interest that are forecastable one period in advance, i.e. $\widehat{v}_t \equiv \mathbb{E}_{t-1}\left(\widehat{\overline{r}}_t\right)$ and $\widehat{v}^*_t \equiv \mathbb{E}_{t-1}\left(\widehat{\overline{r}}^*_t\right)$. Hence, we argue—as most of the literature implicitly does (Woodford (2008))—that $\widehat{v}_t \equiv \widehat{\overline{r}}_t + \widehat{m}_t$ and $\widehat{v}^*_t \equiv \widehat{\overline{r}}^*_t + \widehat{m}^*_t$, where $\widehat{m}_t \equiv \mathbb{E}_{t-1}\left(\widehat{\overline{r}}_t\right) - \widehat{\overline{r}}_t$ and $\widehat{m}^*_t \equiv \mathbb{E}_{t-1}\left(\widehat{\overline{r}}^*_t\right) - \widehat{\overline{r}}^*_t$ define the exogenous, random forecasting error made by the policymakers.

We interpret these Home and Foreign policy forecasting errors, $\widehat{m}_t$ and $\widehat{m}^*_t$, as monetary shocks—stochastic deviations on the stance of monetary policy with respect to the country's natural real rate (with possibly serial autocorrelation in the forecasting errors). We characterize the monetary shock process with the following bivariate VAR(1) process:

$$\begin{pmatrix} \widehat{m}_t \\ \widehat{m}^*_t \end{pmatrix} \approx \begin{pmatrix} \delta_m & 0 \\ 0 & \delta_m \end{pmatrix} \begin{pmatrix} \widehat{m}_{t-1} \\ \widehat{m}^*_{t-1} \end{pmatrix} + \begin{pmatrix} \widehat{\varepsilon}^m_t \\ \widehat{\varepsilon}^{m*}_t \end{pmatrix}, \quad \begin{pmatrix} \widehat{\varepsilon}^m_t \\ \widehat{\varepsilon}^{m*}_t \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2_m & \rho_{m,m^*}\sigma^2_m \\ \rho_{m,m^*}\sigma^2_m & \sigma^2_m \end{pmatrix}\right), \tag{2}$$

where the persistence of the monetary shock depends on δ_m, the volatility of the innovations is given by σ^2_m and the cross-country correlation is ρ_{m,m^*}. This Wicksellian policy specification of the Taylor (1993) rule has the implication that in equilibrium the dynamics of inflation net of its long-run rate (cyclical inflation) and the output gap are fully isolated from the Home and Foreign natural (real) rates and, therefore, unaffected by the TFP shocks in (1). Only the monetary shocks $\widehat{m}_t$ and $\widehat{m}^*_t$ matter for modelling modelling inflation and policy trade-offs.

Furthermore, we assume that the Home and Foreign central banks' (time-varying) inflation targets, $\overline{\pi}_t$ and $\overline{\pi}^*_t$, follow a random walk—that is, $\overline{\pi}_t \approx \overline{\pi}_{t-1} + \widehat{\varepsilon}^\pi_t$ and $\overline{\pi}^*_t \approx \overline{\pi}^*_{t-1} + \widehat{\varepsilon}^{\pi*}_t$, where $\widehat{\varepsilon}^\pi_t$ and $\widehat{\varepsilon}^{\pi*}_t$ are the corresponding Home and Foreign inflation target innovations which follow their own bivariate Gaussian process,

$$\begin{pmatrix} \widehat{\varepsilon}^\pi_t \\ \widehat{\varepsilon}^{\pi*}_t \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2_\pi & 0 \\ 0 & \sigma^2_\pi \end{pmatrix}\right), \tag{3}$$

where the volatility of the inflation target innovations is given by σ^2_π. TFP shock innovations, monetary shock innovations, and inflation target innovations are assumed to be independent of each other.

In equilibrium, the long-run inflation rate prevailing in a given country, $\widehat{\overline{\pi}}_t$ and $\widehat{\overline{\pi}}^*_t$, must be equal to the country's inflation target set by the monetary authorities, i.e. it must be that $\widehat{\overline{\pi}}_t = \overline{\pi}_t$ and $\widehat{\overline{\pi}}^*_t = \overline{\pi}^*_t$, respectively. To see this, let us interpret the (time-varying) long-run inflation rate as the Beveridge-Nelson stochastic trend of the corresponding inflation process, i.e.,

$$\widehat{\overline{\pi}}_t \equiv \lim_{h\to\infty} \mathbb{E}_t\left(\widehat{\pi}_{t+h}\right), \ \widehat{\overline{\pi}}^*_t \equiv \lim_{h\to\infty} \mathbb{E}_t\left(\widehat{\pi}^*_{t+h}\right). \tag{4}$$

The inflation rate of each country, $\widehat{\pi}_t$ and $\widehat{\pi}^*_t$, fluctuates around the corresponding country's stochastic inflation target, $\overline{\pi}_t$ and $\overline{\pi}^*_t$. Since the inflation target is a random walk, it follows that $\mathbb{E}_t\left(\overline{\pi}_{t+h}\right) = \overline{\pi}_t$ and $\mathbb{E}_t\left(\overline{\pi}^*_{t+h}\right) = \overline{\pi}^*_t$ at any period $h > 0$ and as h goes to infinity. As a result, (4) validates the initial conjecture that the (time-varying) long-run inflation rate equals the (random walk) inflation target in every period (Woodford (2008)). Henceforth, we use the notation for the inflation target in place of the one for the long-run inflation rate from this point onwards since the (time-varying) long-run inflation rates must be pin down in equilibrium by the central banks' inflation target.

Given the structure of the economy, inflation in each country is equal to the sum of the country's random walk inflation target plus a cyclical inflation component—$(\widehat{\pi}_t - \overline{\pi}_t)$ and $(\widehat{\pi}^*_t - \overline{\pi}^*_t)$ for Home and Foreign, respectively. The implication of the Wicksellian policy implemented here is that in equilibrium cyclical inflation is driven only by the policy forecasting errors (the monetary shocks) $\widehat{m}_t$ and $\widehat{m}^*_t$. Hence, inflation itself has a non-stationary component that arises from the inflation target and a stationary one on its cyclical part that is driven by the monetary shocks $\widehat{m}_t$ and $\widehat{m}^*_t$.

2.1 Solution Characterization

We define the world aggregate with output-based weights as $\widehat{g}^W_t \equiv \frac{1}{2}\widehat{g}_t + \frac{1}{2}\widehat{g}^*_t$ and label the difference between both countries as $\widehat{g}^R_t \equiv \widehat{g}_t - \widehat{g}^*_t$. From here, it follows that any pair of Home and Foreign variables, $\widehat{g}_t$ and $\widehat{g}^*_t$ respectively, can be decomposed as,

$$\widehat{g}_t = \widehat{g}^W_t + \frac{1}{2}\widehat{g}^R_t,\ \widehat{g}^*_t = \widehat{g}^W_t - \frac{1}{2}\widehat{g}^R_t. \tag{5}$$

Hence, if we solve for $\widehat{g}^W_t$ and $\widehat{g}^R_t$, the transformation in (5) suffices to back out the country variables $\widehat{g}_t$ and $\widehat{g}^*_t$. Then, we orthogonalize the model in Table 1 into one aggregate (or world) economic system for $\widehat{g}^W_t$ and another differential system for $\widehat{g}^R_t$ that are studied separately (as in Martínez-García (2017)).

The NKPC equations for the world and difference systems can be cast into the following form,

$$\widehat{\pi}^s_t - \overline{\pi}^s_t = \beta \mathbb{E}_t\left(\widehat{\pi}^s_{t+1} - \overline{\pi}^s_{t+1}\right) + \Phi\left(\varphi + \gamma\right)\kappa^s \widehat{x}^s_t,\ \text{for } s = W, R, \tag{6}$$

where $\mathbb{E}_t(.)$ is the expectation formed conditional on information up to time t, $\widehat{x}^W_t$ is the global output gap ($\widehat{x}^R_t$ differential slack), $\widehat{\pi}^W_t$ is global inflation ($\widehat{\pi}^R_t$ differential slack), and $\overline{\pi}^W_t$ is the global inflation rate target ($\overline{\pi}^R_t$ differential inflation target). The term $\Phi\left(\varphi+\gamma\right) > 0$ corresponds to the closed-economy Phillips curve slope. Furthermore, $\kappa^W = 1$ determines the NKPC slope on global slack and $\kappa^R \equiv (2\kappa - 1) > 0$ sets the slope on differential slack. The composite $\kappa \equiv (1-\xi)\left[1 - (\sigma\gamma - 1)\left(\frac{\gamma}{\varphi+\gamma}\right)\left(\frac{(2\xi)(1-2\xi)}{1+(\sigma\gamma-1)(2\xi)(2(1-\xi))}\right)\right]$ depends on deep structural parameters but not on the policy parameters (Table 1).

The dynamic IS equations for the world and difference systems are given by,

$$\widehat{x}^s_t = \mathbb{E}_t\left[\widehat{x}^s_{t+1}\right] - \frac{\Omega^s}{\gamma}\left(\widehat{i}^s_t - \mathbb{E}_t\left[\widehat{\pi}^s_{t+1}\right] - \widehat{\overline{r}}^s_t\right),\ \text{for } s = W, R, \tag{7}$$

where $\widehat{i}^W_t$ is the world aggregate short-term nominal interest rate ($\widehat{i}^R_t$ differential nominal interest rate), and $\widehat{\overline{r}}^W_t$ is the world natural real rate ($\widehat{\overline{r}}^R_t$ differential natural real rate). Furthermore, $\Omega^W = 1$ determines the dynamic IS slope on the world real interest rate gap—the slope on $\left(\widehat{i}^W_t - \mathbb{E}_t\left[\widehat{\pi}^W_{t+1}\right]\right) - \widehat{\overline{r}}^W_t$—while $\Omega^R \equiv (2\Omega - 1) > 0$ is the slope on the differential real interest rate gap—the slope on $\left(\widehat{i}^R_t - \mathbb{E}_t\left[\widehat{\pi}^R_{t+1}\right]\right) - \widehat{\overline{r}}^R_t$. As indicated in Table 1, the composite coefficient $\Omega \equiv (1-\xi)\left(\frac{1-2\xi(1-\sigma\gamma)}{1-2\xi}\right)$ depends on deep structural parameters related to bilateral trade but not on the policy parameters.

Finally, we complete the representation of the orthogonalized model with the Taylor (1993) rules for the world and difference systems which can be written as follows,

$$\widehat{i}_t^s = \widehat{r}_t^s + \overline{\pi}_t^s + \psi_\pi \left(\widehat{\pi}_t^s - \overline{\pi}_t^s \right) + \psi_x \widehat{x}_t^s + \widehat{m}_t^s, \text{ for } s = W, R, \tag{8}$$

where $\overline{\pi}_t^W$ is the world's aggregate inflation target ($\overline{\pi}_t^R$ differential inflation target), and $\widehat{m}_t^W$ can be interpreted as aggregate innovations on the stance of monetary policy ($\widehat{m}_t^R$ differential monetary innovations).

Assuming existence and uniqueness are guaranteed, the solution of the model can be characterized as:[8]

$$\begin{pmatrix} \widehat{x}_t^s \\ \widehat{\pi}_t^s \end{pmatrix} = \begin{pmatrix} 0 \\ \overline{\pi}_t^s \end{pmatrix} + \sum_{j=0}^{\infty} \left(A^s \right)^j a^s \mathbb{E}_t \left(\widehat{m}_{t+j}^s \right), \text{ for } s = W, R, \tag{9}$$

whenever $\lim_{j \to \infty} \left(A^s \right)^j \mathbb{E}_t \left(\widehat{z}_{t+j}^s \right) = 0$. The matrices of structural parameters defined as $a^s \equiv -\Psi^s \begin{pmatrix} \frac{\Omega^s}{\gamma} \\ \frac{\Omega^s}{\gamma} \Phi \left(\varphi + \gamma \right) \kappa^s \end{pmatrix}$ and $A^s \equiv \Psi^s \begin{pmatrix} 1 & \frac{\Omega^s}{\gamma} \left(1 - \beta \psi_\pi \right) \\ \Phi \left(\varphi + \gamma \right) \kappa^s & \frac{\Omega^s}{\gamma} \Phi \left(\varphi + \gamma \right) \kappa^s + \beta \left(1 + \frac{\Omega^s}{\gamma} \psi_x \right) \end{pmatrix}$ characterize the cyclical dynamics of the model. Each country's central bank sets its monetary policy rule to align nominal interest rates with the country's natural rate and its own inflation target, while responding to deviations of actual inflation from target and to the local slack accumulated. Disturbances to the policy rule (our notion of monetary shocks) modeled as autoregressive processes in (3) are intended to capture (possibly-)persistent and unanticipated changes in the stance of monetary policy. In such a monetary policy framework, the solution to the system in (9) leads to the following policy trade-off in equilibrium:

Proposition 1 *Given the solution of the world and differential systems in* (9)*, the following trade-off between inflation and slack arises in equilibrium*

$$\widehat{\pi}_t^s - \overline{\pi}_t^s = \left(\frac{\Phi \left(\varphi + \gamma \right) \kappa^s}{1 - \beta \delta_m} \right) \widehat{x}_t^s, \textit{ for all } s = W, R, \tag{10}$$

which indicates that aggregate inflation in deviations from target and global slack comove—differential inflation in deviations from target and differential slack comove too. The slope of the NKPC equations $\Phi \left(\varphi + \gamma \right) \kappa^s$ for $s = W, R$ enters the constant of proportionality implied by (10) *in equilibrium together with a scaling term whenever monetary shocks display some persistence ($\delta_m \neq 0$) since* $0 < \beta < 1$.

Proof. See the accompanying on-line Appendix. ∎

The theoretical relationship postulated in (10) arises from the solution of the workhorse two-country New Keynesian model, but the principle underlying the result is more general and applicable to a large class of related open-economy models. We can go a step further now and use the transformation in (5) to back out the equilibrium implications of Proposition 1 at the country level as follows:

[8]For a detailed derivation of the full solution and its corresponding determinacy region, the interested reader is referred to the accompanying on-line appendix to this paper.

Proposition 2 *We find that the cyclical component of inflation in each country satisfies that:*

$$\widehat{\pi}_t - \overline{\pi}_t = \left(\frac{\Phi(\varphi+\gamma)}{1-\beta\delta_m}\right)\left(\widehat{x}_t^W + \frac{1}{2}\kappa^R \widehat{x}_t^R\right) = \left(\frac{\Phi(\varphi+\gamma)}{1-\beta\delta_m}\right)\left[\kappa \widehat{x}_t + (1-\kappa)\,\widehat{x}_t^*\right], \tag{11}$$

$$\widehat{\pi}_t^* - \overline{\pi}_t^* = \left(\frac{\Phi(\varphi+\gamma)}{1-\beta\delta_m}\right)\left(\widehat{x}_t^W - \frac{1}{2}\kappa^R \widehat{x}_t^R\right) = \left(\frac{\Phi(\varphi+\gamma)}{1-\beta\delta_m}\right)\left[(1-\kappa)\,\widehat{x}_t + \kappa \widehat{x}_t^*\right], \tag{12}$$

which shows that the slope (on the own country's slack) of the NKPC equations determined by the composite coefficient $\kappa \equiv (1-\xi)\left[1-(\sigma\gamma-1)\left(\frac{\gamma}{\varphi+\gamma}\right)\left(\frac{(2\xi)(1-2\xi)}{1+(\sigma\gamma-1)(2\xi)(2(1-\xi))}\right)\right]$ *in Table 1 is fundamental to characterize the relationship between local inflation and world slack in equilibrium.*

Equations $(11)-(12)$ also show that output-weighted measures of global slack ($\widehat{x}_t^W \equiv \frac{1}{2}\widehat{x}_t + \frac{1}{2}\widehat{x}_t^*$) do not properly account for the model-implied relationship between domestic inflation on the one hand and Home and Foreign slack ($\widehat{x}_t$ and $\widehat{x}_t^*$, respectively) on the other hand. In turn, Proposition 2 suggests that the theoretically-consistent weighting of Home and Foreign slack must be based on the slope of the open-economy Phillips curve through the composite coefficient κ. In the special case of perfect international risk-sharing where we assume $\sigma\gamma = 1$ (Cole and Obstfeld (1991)), we find that the slope of the open-economy Phillips curve $\kappa \equiv (1-\xi)$ is a straightforward function of the degree of trade openness $0 \leq \xi \leq \frac{1}{2}$.[9] This implies that the relationship between inflation and slack in Proposition 2 can be re-expressed using a simple trade-weighted measures of global slack, $((1-\xi)\,\widehat{x}_t + \xi\widehat{x}_t^*)$ for the Home country and $(\xi\widehat{x}_t + (1-\xi)\,\widehat{x}_t^*)$ for the Foreign country. This illustrates that trade weights play a role in equilibrium balancing out the complex international linkages between domestic and foreign slack in relation to local inflation—however, we should note that trade-weights need to be adjusted based on how trade affects the slope of the open-economy Phillips curve κ as implied by $(11)-(12)$ which is a more complex relationship whenever $\sigma\gamma \neq 1$.

Proposition 2 offers also an important insight on inflation modelling for policy analysis. This theoretical result suggests that the nature of weighted global slack and its relationship with local inflation are largely determined by international trade (through adjusted-trade weights based on the composite κ)—a point that is often ignored in the literature. In this sense, theory clearly indicates that trade integration is an important channel for the transmission of global factors into local inflation.

2.2 Main Implications

Optimal forecasts at time t of world and differential inflation h-quarters-ahead (for any horizon $h \geq 1$) are:

$$\mathbb{E}_t\left(\widehat{\pi}_{t+h}^s\right) = \overline{\pi}_t^s = \widehat{\pi}_t^s - \left(\frac{\Phi(\varphi+\gamma)}{1-\beta\delta_m}\right)\kappa^s \widehat{x}_t^s, \text{ for } s = W, R, \tag{13}$$

which, simply re-arranging, implies that,

$$\mathbb{E}_t\left(\widehat{\pi}_{t+h}^s - \widehat{\pi}_t^s\right) = -\left(\frac{\Phi(\varphi+\gamma)}{1-\beta\delta_m}\right)\kappa^s \widehat{x}_t^s, \text{ for } s = W, R. \tag{14}$$

These forecasts are efficient—they cannot be improved with additional information: no variable other than output-weighted world slack, $\widehat{x}_t^W$, helps improve the forecast of changes in output-weighted world inflation

[9] For a discussion on the plausibility of $\sigma\gamma = 1$ in the context of parameterizing the workhorse open-economy New Keynesian model, we refer the interested reader to Kabukçuoğlu and Martínez-García (2016).

h-periods ahead, $\widehat{\pi}_{t+h}^{W} - \widehat{\pi}_{t}^{W}$; similarly, no variable other than the difference between Home and Foreign slack, $\widehat{x}_{t}^{R}$, should improve the forecast of changes in the inflation differential, $\widehat{\pi}_{t+h}^{R} - \widehat{\pi}_{t}^{R}$.[10]

Then, using the transformation in (5), an efficient time t forecast of domestic inflation h-quarters-ahead, $\widehat{\pi}_{t+h}$, can be achieved based on the following single-equation specification,

$$\mathbb{E}_t \left(\widehat{\pi}_{t+h} - \widehat{\pi}_t \right) = \mathbb{E}_t \left(\widehat{\pi}_{t+h}^{W} - \widehat{\pi}_{t}^{W} \right) + \frac{1}{2} \mathbb{E}_t \left(\widehat{\pi}_{t+h}^{R} - \widehat{\pi}_{t}^{R} \right) = - \left(\frac{\Phi \left(\varphi + \gamma \right)}{1 - \beta \delta_m} \right) \left(\widehat{x}_{t}^{W} + \frac{1}{2} \kappa^{R} \widehat{x}_{t}^{R} \right), \tag{15}$$

using equations $(13) - (14)$. Furthermore, equation (15) can also be written as,

$$\mathbb{E}_t \left(\widehat{\pi}_{t+h} - \widehat{\pi}_t \right) = - \left(\frac{\Phi \left(\varphi + \gamma \right)}{1 - \beta \delta_m} \right) \left[\kappa \widehat{x}_t + \left(1 - \kappa \right) \widehat{x}_{t}^{*} \right]. \tag{16}$$

The forecasting equation in (16) indicates that expected changes in domestic inflation over the next h-periods can be efficiently forecasted with a weighted measure of Home and Foreign slack (i.e., a weighted measure of $\widehat{x}_t$ and $\widehat{x}_t^{*}$ respectively) where the weights are determined by the slope of the open-economy Phillips curve, κ—which is functionally-related to the degree of trade openness $0 \leq \xi \leq \frac{1}{2}$ but it depends on other structural parameters like the trade elasticity $\sigma > 0$ and even the inverse of the Frisch elasticity of labor supply $\varphi > 0$. The weights are not affected otherwise by the policy parameters.[11]

Computing global slack with appropriate weights suffices to predict domestic inflation changes as implied by (16), but it is not easy to do in practice—due to data limitations and the difficulties associated with pinning down the theoretically-consistent weights whenever those deviate from simple trade-weights (which occurs if $\sigma\gamma \neq 1$). To mitigate some of these limitations that arise with the concept of global slack, we rely on the following insight from the workhorse open-economy New Keynesian model: if there exists an open-economy Phillips curve relationship linking global inflation and global slack (as implied by (10)), then some measure of global inflation should have information content about the unobserved (or imperfectly-measured) global slack that can be exploited for forecasting domestic inflation.

We propose a straightforward modification of the Phillips-curve-type equilibrium forecasting equations introduced in $(11) - (12)$ in order to obtain a more practical and easier-to-measure forecasting specification based on global inflation. The forecasting equations described in (14) can be combined with the Phillips-curve-type relationship relating world slack to global inflation in equation (10)—computed with output-based weights in both cases—and re-expressed as follows,

$$\begin{aligned} \mathbb{E}_t \left(\widehat{\pi}_{t+h} - \widehat{\pi}_t \right) &= \mathbb{E}_t \left(\widehat{\pi}_{t+h}^{W} - \widehat{\pi}_{t}^{W} \right) + \frac{1}{2} \mathbb{E}_t \left(\widehat{\pi}_{t+h}^{R} - \widehat{\pi}_{t}^{R} \right) \\ &= - \left(\frac{\Phi \left(\varphi + \gamma \right)}{1 - \beta \delta_m} \right) \widehat{x}_{t}^{W} - \frac{1}{2} \left(\frac{\Phi \left(\varphi + \gamma \right)}{1 - \beta \delta_m} \right) \kappa^{R} \widehat{x}_{t}^{R} \text{ using } (14) \\ &= - \left(\widehat{\pi}_{t}^{W} - \overline{\pi}_{t}^{W} \right) - \frac{1}{2} \left(\frac{\Phi \left(\varphi + \gamma \right)}{1 - \beta \delta_m} \right) \kappa^{R} \widehat{x}_{t}^{R} \text{ using } (10) \text{ for } s = W, \end{aligned} \tag{17}$$

[10] Forecasting future inflation using output gaps alone can be a concern since inflation has a stochastic trend while slack is stationary. Including current inflation to forecast future inflation takes care of the trend component without having to add additional regressors. That is why the forecasting equation presented here (and all subsequent variants) is expressed in terms of changes in the local inflation rate.

[11] Hence, the measure of output-weighted world slack $\widehat{x}_{t}^{W} \equiv \frac{1}{2} \widehat{x}_t + \frac{1}{2} \widehat{x}_{t}^{*}$ that we use to orthogonalize the model solution is not sufficient for forecasting changes in domestic inflation if we use want to use a measure of global slack, according to equation (16).

where $\kappa^R \equiv (2\kappa - 1) > 0$ is defined as a function of the composite $\kappa \equiv (1-\xi)\left[1-(\sigma\gamma-1)\left(\frac{\gamma}{\varphi+\gamma}\right)\left(\frac{(2\xi)(1-2\xi)}{1+(\sigma\gamma-1)(2\xi)(2(1-\xi))}\right)\right]$. Furthermore, the equation in (16) can be re-written using equation (10) to generate a simpler forecasting model based on output-weighted global inflation and domestic slack alone as follows,

Proposition 3 *The forecasting equation in* (16) *combined with the Phillips Curve-type relationship in* (10) *implies that:*

$$\begin{aligned}
\mathbb{E}_t\left(\widehat{\pi}_{t+h} - \widehat{\pi}_t\right) &= -\left(\frac{\Phi\left(\varphi+\gamma\right)}{1-\beta\delta_m}\right)\left[\kappa\widehat{x}_t - (2\kappa-1)\,\widehat{x}_t + (1-\kappa)\,\widehat{x}^*_t + (2\kappa-1)\,\widehat{x}_t\right] \\
&= -2\,(1-\kappa)\left(\frac{\Phi\left(\varphi+\gamma\right)}{1-\beta\delta_m}\right)\widehat{x}^W_t - \left(\frac{\Phi\left(\varphi+\gamma\right)}{1-\beta\delta_m}\right)(2\kappa-1)\,\widehat{x}_t \text{ re-writting (16)} \\
&= -2\,(1-\kappa)\left(\widehat{\pi}^W_t - \overline{\pi}^W_t\right) - \left(\frac{\Phi\left(\varphi+\gamma\right)}{1-\beta\delta_m}\right)(2\kappa-1)\,\widehat{x}_t \text{ using (10) for } s = W, \qquad (18)
\end{aligned}$$

where the composite coefficient $\kappa \equiv (1-\xi)\left[1-(\sigma\gamma-1)\left(\frac{\gamma}{\varphi+\gamma}\right)\left(\frac{(2\xi)(1-2\xi)}{1+(\sigma\gamma-1)(2\xi)(2(1-\xi))}\right)\right]$ *depends on the degree of openness* $0 \leq \xi \leq \frac{1}{2}$ *and other structural parameters of the model, but not on the policy parameters. In the special case where* $\sigma\gamma = 1$*, the forecasting equation in* (18) *reduces to* $\mathbb{E}_t\left(\widehat{\pi}_{t+h} - \widehat{\pi}_t\right) = -2\xi\left(\widehat{\pi}^W_t - \overline{\pi}^W_t\right) - \left(\frac{\Phi(\varphi+\gamma)}{1-\beta\delta_m}\right)(1-2\xi)\,\widehat{x}_t$ *whose coefficients are a function of* ξ *and the term* $\left(\frac{\Phi(\varphi+\gamma)}{1-\beta\delta_m}\right)$ *(a persistence-scaled transformation of the slope of the closed-economy Phillips curve).*

The forecasting model in (18) depends on output-weighted world inflation in deviations from target, $\left(\widehat{\pi}^W_t - \overline{\pi}^W_t\right)$, and on domestic slack, $\widehat{x}_t$. The forecasting model in (18) motivates us to use different domestic slack measures together with a variety of weighted global inflation for forecasting domestic inflation. Here, Proposition 3 illustrates that using a simple weighting scheme based on economic size alone (output weights) to compute global inflation in deviations is sufficient to obtain an efficient forecast of local inflation when combined with domestic slack. Moreover, this result also suggests that an optimal aggregation scheme to achieve efficient inflation forecasts does not require that we rely on trade-weights (whenever $\sigma\gamma = 1$) or some other more complex form of trade-based weights (whenever $\sigma\gamma \neq 1$).

Finally, it is important to point out also that declines in the composite coefficient $\kappa \geq \frac{1}{2}$ alter the contribution of output-weighted global inflation and domestic slack in the forecasting model given in (18). In fact, we observe that a lower κ implies that the contribution to inflation forecasting of output-weighted global inflation goes up while the contribution of domestic slack goes down (given (18)). Declines in κ occur here as a result of increases in the degree of openness of $0 \leq \xi \leq \frac{1}{2}$ (globalization), albeit the magnitude of the decline depends on other structural parameters of the model (particularly on the trade elasticity $\sigma > 0$ and the inverse of the Frisch elasticity of labor supply $\varphi > 0$). Declines in κ are interpreted as a flattening of the Phillips curve, a feature of the data since the early 1980s empirically docummented by Roberts (2006), among others. Not surprisingly, this last observation indicates that output-weighted global inflation should play a more dominant role than domestic slack during our sample time coverage over the Great Moderation due in part to the observed flattening of the Phillips curve (associated with globalization) of this period—as the evidence presented in the rest of the paper suggests.

The theory laid out here provides guidance for policy analysis and enhances our understanding of the factors driving inflation—all of which facilitates our empirical work (on forecasting) along these lines:

1. Several recent papers have proposed Bayesian VARs (and related models) containing foreign vari-

ables for forecasting inflation (Banbura et al. (2010), Duncan and Martínez-García (2015)). In here, we argue that a single-equation specification motivated by theory may indeed suffice for forecasting domestic inflation and can provide as efficient a forecast as a richer VAR specification.

2. Kabukçuoğlu and Martínez-García (2016) argue that global slack matters for modelling inflation and for forecasting—while warning us about data limitations, among other concerns. Our paper indicates that weighting slack appropriately based on the slope of the open-economy Phillips curve to construct theoretically-consistent aggregates can improve the forecasting performance of global-slack based models. In our benchmark, trade-weighted global slack is a sufficient forecasting regressor whenever $\sigma\gamma = 1$ while a more complex weighting scheme based on trade is required if $\sigma\gamma \neq 1$.

3. Whenever global slack cannot be reliably measured and consistently weighted according to theory, an alternative forecasting model based on global inflation can be exploited instead (equation (18)). We also observe that economic size rather than the strength of the trade linkages suffices to construct theoretically-consistent weighted measures of global inflation for forecasting. Our paper, therefore, provides a novel theoretical basis for the growing strand of the empirical literature on inflation forecasting that relies on measures of global inflation (Ciccarelli and Mojon (2010), Ferroni and Mojon (2014)). However, forecasting equation (18) (and similarly for (17)) indicate that global inflation alone does not suffice to obtain an efficient forecast of domestic inflation. Forecasts based on output-weighted global inflation can be further improved with either a reliable measure of differential slack, $\widehat{x}_t^R$, or—most relevant for our posterior empirical analysis—with a measure of domestic slack, $\widehat{x}_t$.

4. We show that the coefficients on the resulting single-equation forecasting model in (18) depend on the degree of openness ξ with, *ceteris paribus*, a higher contribution from output-weighted global inflation and a lower contribution from domestic slack for countries with higher degree of openness ξ. The magnitude of those shifts depends more generally on the slope of the open-economy Phillips curve κ, which means that other structural parameters of the model (particularly on the trade elasticity $\sigma > 0$ and the inverse of the Frisch elasticity of labor supply $\varphi > 0$) also affect the relative contributions of both predictors. Moreover, we also note that the contribution of slack to forecasting also depends on the slope of the closed-economy Phillips curve corrected to account for the effect of monetary shock persistence through the term $\left(\frac{\Phi(\varphi+\gamma)}{1-\beta\delta_m}\right)$. Hence, the flatter the open-economy Phillips curve (through increased globalization) or the flatter the closed-economy Phillips curve (through a higher degree of price stickiness α or perhaps through a higher elasticity of labor supply φ^{-1}), the less significant the forecasting contribution from domestic slack is going to be everything else equal. Hence, to some extent this observation reconciles the model predictions with our empirical evidence showing that most of the contribution to improved forecasting efficiency is achieved with global inflation over the Great Moderation (a period characterized by the perceived flattening of the Phillips curve).

5. Finally, we argue that there is a crucial lesson for policy-making as well in the inflation forecasting model given by (18) (or (17))—that the sensitivity of inflation forecasts to their predictors is invariant to the monetary policy rule parameters ψ_π and ψ_x. The central bank helps anchor inflation expectations setting a credible (yet time-varying) inflation target and this underpins the equilibrium relationships derived in $(11) - (12)$. Monetary policy shocks are in turn the key driving force behind Home and Foreign cyclical inflation and Home and Foreign slack. Hence, if indeed the structural

coefficients on the alternative forecasting models are otherwise invariant to the policy parameters in the Taylor (1993) rule, this implies that the formation of expectations on inflation is also invariant to the precise anti-inflation bias of the monetary policy rule, everything else equal. Therefore, credible inflation-targeting central banks can alter the trade-off among their short-term policy aims (in terms of inflation and slack) without communicating with it a change in the contribution of the predictors to the expected path of inflation. This is an important insight for policy evaluation that has generally not been recognized in the previous literature.

3 Empirical Strategy

3.1 Data

We use two standard measures of inflation: the headline consumer price index (CPI) and the core CPI (CPI ex. food and energy). The inflation rate is calculated in terms of annualized log-differences on the quarterly series of each of the price indexes that we consider (headline CPI and core CPI) expressed in percentages. Our data also includes a number of forecasting regressors such as slack measures based on real GDP and industrial production (IP) data. Slack is proxied with the detrended real GDP or the detrended IP series of each country: Detrending is performed using a 1-sided HP filter (based on the Kalman filter approach described by Stock and Watson (1999)) and also through first-differencing of the series in logs (expressed in percentages in both cases). Data on headline and core CPI as well as real GDP and IP series for all countries are obtained from the Federal Reserve Bank of Dallas' Database of Global Economic Indicators (DGEI).[12]

We perform inflation forecasts using global slack measures based on weighted averages of the country-level detrended real GDP or IP series. As an alternative measure of global economic slack, we use Kilian (2009)'s index of global economic conditions obtained from Lutz Kilian's website. We also perform inflation forecasts with oil prices using the West Texas Intermediate Crude Oil series obtained through the St. Louis Fed's FRED database. We use the 1-sided HP filter and first-differencing in logs with the oil series as well—but not with Kilian (2009)'s index. For all variables, we use quarterly series for the 1984:Q1-2015:Q1 period.

We forecast domestic inflation for a group of 14 countries: Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and United States. We report our findings for the U.S. and a summary of the evidence for this group of 14 advanced economies. When we construct the global inflation and slack measures for each one of these 14 countries, we take advantage of the broader country coverage in the Federal Reserve Bank of Dallas' DGEI dataset and consider a larger group of countries for which there is data available. The countries included in the calculations of the global aggregates are selected depending on the consistency of data available for each inflation and inflation-predictor series and includes a larger group of up to 29 countries (including the 14 advanced countries as well as some emerging economies).[13]

The weighting scheme is crucial to incorporate all relevant international linkages into the aggregates used in our forecasting models, as implied by theory. We construct weights for our global aggregates

[12]Details on the sources and methodology are given in Grossman et al. (2014). The Federal Reserve Bank of Dallas' DGEI database can be accessed at: https://www.dallasfed.org/institute/dgei/

[13]These countries are Australia, Austria, Belgium, Canada, Chile, China, Colombia, France, Germany, Greece, Hungary, India, Indonesia, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Philippines, Poland, Portugal, South Africa, Spain, Sweden, Switzerland, Taiwan, the United Kingdom, and the U.S.

based on standard trade linkages. However, the choice of the weights can be important also to capture unmodelled aspects of the interconnectedness across countries that are not fully reflected in the stylized open-economy workhorse New Keynesian model that motivates our paper. The selection of an appropriate weighting scheme is, therefore, of great practical importance for forecasting. Not surprisingly, such choices have featured prominently in the literature on forecast combination—for instance, Stock and Watson (2004) and D'Agostino and Surico (2009), among others, argue that equal weighting generally yields among the best forecasting outcomes across different specifications when the exact weights are otherwise unknown or uncertain.

For these and related reasons, we find it important to consider alternative weighting schemes based on "proximity" across countries (such as through geographic distance), based on other economic-size-adjusted metrics (such as population-weighted geographic distance), and even based on atheoretical specifications (such as the equal weights noted by Stock and Watson (2004) and D'Agostino and Surico (2009)). To be more precise, we use five different weighting schemes:[14]

(i) equal weights;

(ii) weights based on contiguity data describing whether each pair of countries shares a common border or not from the GeoDist database (see Mayer and Zignago (2011));

(iii) weights constructed from the inverse of the square of the geographic distance between country pairs using data from the GeoDist database (see Mayer and Zignago (2011));

(iv) weights constructed from the inverse of the square of geographic distance weighted by population between country pairs from the GeoDist database (see Mayer and Zignago (2011)); and

(v) trade weights based on the average trade (imports plus exports) world shares over the period 1984-2014 (using the annual IMF Direction of Trade (DOT) nominal merchandise series quoted in U.S. dollars).

See the Appendix to the paper (and the companion on-line Appendix) for further details on the sources and country composition of the data used in our various forecasting exercises and for other technical aspects of the aggregation procedure.

3.2 Main Forecasting Models

We simplify the notation here defining $\pi_{i,t}$ as the inflation rate for country $i = 1, ..., N$ at quarter $t = 1, ..., T$.[15] We compute the h-quarter ahead (annualized) inflation rate for country i as $\pi_{i,t+h} \equiv \frac{400}{h} \times \left[\ln\left(\frac{P_{i,t+h}}{P_{i,t}}\right)\right]$. For a given quarterly forecast horizon h ranging from 1-quarter ahead to 12-quarters ahead and a given country i, we denote the country i inflation forecast h-quarters ahead that uses all information up to quarter t as $\pi^{k}_{i,t+h|t}$. This forecast is obtained under a given forecasting model indexed by the super-script k. N corresponds to the 14 countries for which we have all relevant data for our forecasting performance comparison, while T denotes our sample size.

The importance of the international linkages that arises from our theoretical results extends more generally to a larger class of open-economy New Keynesian models with richer dynamic structures. We take account of this by also modelling a temporal dimension into our empirical forecasting specifications aimed at capturing those richer (yet unmodelled) dynamics. We do this with an autoregressive distributed lag

[14]The weights used in the construction of any global aggregate for a given country-specific forecasting model are adjusted to sum up to 1.

[15]We drop the 'hat' on the variables from now on to keep notation to a minimum, unless otherwise noted.

(ADL) specification where we use a conventional procedure (Schwarz Information Criterion, henceforth SIC) to optimally choose the appropriate number of lags. Then, we consider the following empirical specifications for our forecast evaluation exercise:

1. First, we introduce as our benchmark a simple autoregressive (AR) model to predict inflation (with no international linkages or economic predictors), i.e.,

$$\pi^1_{i,t+h|t} = c^1_i + \sum_{s=0}^{p} \gamma^1_{i,s} \pi_{i,t-s} + \epsilon^1_{i,t+h}, \text{ for country } i \text{ and horizon } h, \tag{Model 1}$$

   which forecasts future inflation solely with the distributed lag of earlier inflation rates $\pi_{i,t}$. The optimal number of lags p is selected based on the SIC. To keep the model parsimonious and since we work with quarterly series, the maximum possible lags allowed is set at four. We use the lag length selected under this benchmark with all other models to keep them nested in our forecasting exercises. We often refer to this as the naïve forecasting model.

This naïve forecasting model serves as the nested benchmark against which we compare the accuracy gains of our alternative open-economy Phillips curve-based forecasting specifications. This naïve model arises as a natural benchmark to evaluate the role played on local inflation by global macroeconomic factors through international linkages. With this benchmark model, we aim to assess the value-added of modelling an international (cross-sectional) dimension of domestic inflation—implied by the open-economy New Keynesian model—against the information content on inflation forecasting that arises solely from the temporal dimension (i.e., from the autoregressive dynamics alone).[16]

2. The second model we evaluate is an open-economy Phillips curve specification based on global slack. To be more specific, here we are motivated by the conventional implications of the open-economy Phillips curve to study the global output linkages in forecasting domestic inflation, i.e.,

$$\pi^2_{i,t+h|t} = c^2_i + \sum_{s=0}^{p} \gamma^2_{i,s} \pi_{i,t-s} + \sum_{s=0}^{q} \psi^2_{i,s} y^*_{i,t-s} + \epsilon^2_{i,t+h}, \text{ for country } i \text{ and horizon } h. \tag{Model 2}$$

   The specification of Model 2 is referred to as an economic model (unlike Model 1), under the terminology of Stock and Watson (2003a), because it incorporates explanatory economic variables for forecasting domestic inflation. In this case, for each country i, we forecast h-quarters ahead inflation with the distributed lag of earlier inflation rates, $\pi_{i,t}$, and the distributed lag of the explanatory variable, $y^*_{i,t}$, where we define $y^*_{i,t}$ as global slack—the weighted average of domestic slack measures given by $\sum_{j=1}^{M} w^y_{ij} y_{j,t}$. We use the SIC to select the optimal number of lags q for the explanatory economic variable, with the maximum possible lags allowed set at four. The optimal lag length for local inflation dynamics p is the same as for Model 1.

We denote the weights used to construct the global slack measure for forecasting inflation in country i as w^y_{ij}, for all $j = 1, ..., M$ where M corresponds to the sample of up to 29 countries for which we can draw data to construct our aggregates (as noted earlier). Here, the specification of Model 2 incorporates global slack

[16] If inflation is stationary, a parsimonious ARMA(p, q) representation of inflation is found to be a good benchmark for forecasting. See, for example, Ang et al. (2007), D'Agostino and Surico (2009), Rossi and Sekhposyan (2010), Faust and Wright (2013), and also Martínez-García (2017) on theoretical grounds.

as a explanatory variable into the forecasting framework laid out in Model 1 and both models are nested for comparison purposes. Global slack measures, in particular, are a natural predictor of local inflation that conceptually arises from the open-economy New Keynesian framework. Global slack explicitly recognizes that most economies in the world have become more integrated through trade linkages with each other and factors that into a straightforward weighted indicator of global slack for forecasting.

We consider Model 3 which also describes an economic model in the sense of Stock and Watson (2003a) based on the open-economy Phillips curve. This specification incorporates the forecasting predictions of the open-economy New Keynesian model into a more tractable empirical specification that relies on observable global inflation and domestic slack. This forecasting model (our preferred specification) can be estimated with alternative measures of domestic slack and of weighted aggregate inflation (through the weighting scheme given by w_{ij}^{π}). These weights can also be specified to appropriately capture the interconnectedness between inflation across countries in empirically relevant ways.

For the global inflation measure relevant for country i's forecasts, we note that a straightforward rewriting of the forecasting equation in (18) indicates that global inflation can be expressed instead as a convex combination of domestic inflation and a weighted measure of rest-of-the world inflation. We consider weights w_{ij}^{π} which are consistent with the weights for global slack except for a country's own weight which is set equal to zero (i.e., $w_{ii}^{\pi} = 0$) in order to compute our measures of rest-of-the-world inflation—in turn, the contribution of domestic inflation is subsumed in the autoregressive component of our empirical ADL specification. Hence, weighted aggregate inflation defined as $\pi_{i,t}^{*}$ is our rest-of-the-world inflation measure. Also, all other country weights other than the own-country weight are re-scaled to maintain the principle that they should sum up to 1 (i.e., $w_{ij}^{\pi} = \frac{w_{ij}^{y}}{1-w_{ii}^{y}}$ for any country $j \neq i$).

3. Our main model takes into account the spatio-temporal dimensions of the open-economy Phillips curve for forecasting inflation in each country $i = 1, ..., N$, with an ADL specification of domestic inflation, $\pi_{i,t}$ in country i, rest-of-the-world (weighted) inflation, $\pi_{i,t}^{*}$, and domestic slack, $y_{i,t}$, i.e.,

$$\pi_{i,t+h|t}^{3} = c_i^3 + \sum_{s=0}^{p} \gamma_{i,s}^{3} \pi_{i,t-s} + \sum_{s=0}^{z} \lambda_{i,s}^{3} \pi_{i,t-s}^{*} + ... \qquad \text{(Model 3)}$$
$$\sum_{s=1}^{z} \psi_{i,s}^{3} y_{i,t-s} + \epsilon_{i,t+h}^{3}, \text{ for country } i \text{ and horizon } h.$$

The right-hand side of Model 3 augments that of Model 1 with the introduction of an additional pair of regressors, $\pi_{i,t}^{*}$ and $y_{i,t}$, with coefficients $\lambda_{i,s}^{3}$ and $\psi_{i,s}^{3}$ respectively with up to z lags. We calculate the rest-of-the-world inflation as $\pi_{i,t}^{*} = \sum_{j=1}^{M} w_{ij}^{\pi} \pi_{j,t}$. We also use the SIC to select the optimal number of lags z for the economic variables in the specification with the maximum possible lags allowed set at four, taking as given the optimal p determined based on the SIC applied to Model 1. Needless to say, Model 3 reduces to Model 1 if we set $\lambda_{i,s}^{3} = 0$ and $\psi_{i,s}^{3} = 0$ for all $s = 1, ..., z$.

Global inflation alone does not suffice to efficiently forecast domestic inflation as indicated before given the alternative open-economy Phillips curve-based model specifications laid out in equation (18). An efficient forecast would therefore require us to use rest-of-the-world inflation and domestic slack in this framework, although we expect—based on theory—the role of domestic slack to be of secondary importance whenever the Phillips curve tends to be flatter (the relevant case for most countries in our sample).

3.3 Forecasting Evaluation Procedure

We evaluate performance on the basis of multi-step pseudo out-of-sample inflation forecasts with recursive samples. At any given date t, we forecast inflation at date $t + h$ for any given horizon $h = 1, ..., 12$ using all available data up to date t.[17] Let $\underline{T}$ denote the starting date of the full sample and $\overline{T}$ denote the end date. The initial estimation sample for our pseudo out-of-sample procedure starts at $\underline{T}$ and ends at $t_0 < \overline{T}$. We use all data up to date t_0 to forecast inflation at date $t_0 + h$ for a given forecasting horizon h. Then, we add one additional observation to the estimation sample, re-estimate the parameters of the forecasting model with that extra observation (up to date $t_0 + 1$), and obtain an $h-$quarter ahead inflation forecast for date $t_0 + 1 + h$. The recursive implementation of the $h-$quarter ahead inflation forecast continues by adding one additional observation at a time until period $\overline{T} - h$ which generates a total of $\overline{T} - h - t_0 + 1$ forecasts.

In our forecasting exercise where we predict headline and core CPI inflation, the estimation sample begins in 1984:Q1 and ends in 1996:Q4 and the pseudo out-of-sample forecasting period begins in 1997:Q1 and ends in 2015:Q1. This leaves us with an estimation sample of 52 quarters and a pseudo out-of-sample forecasting sample of 73 quarters. The lag length of domestic inflation is determined in Model 1 based on the SIC, and is used as input for the lag length of domestic inflation in the economic models (Model 2 and Model 3)—in this way, the economic models Model 2 and Model 3 are nested into Model 1. The lag length of additional variable(s) included in either Model 2 or Model 3 is set independently based on the SIC. All specifications described in Model 1, Model 2, Model 3 can be estimated by OLS.

For all models $k = 1, 2, 3$, for each country $i = 1, ..., N$, and for any horizon $h = 1, ..., 12$, our iterative procedure yields a sequence of forecasting errors, $\left\{ \widehat{\epsilon}^{k}_{i,t+h} \right\}_{t=t_0}^{\overline{T}-h}$, which we use to construct the mean squared forecasting error (MSFE) of model k and country i at each forecasting horizon h from date t_0 to $\overline{T} - h$ as:

$$MSFE^{k}_{i,h} \equiv \frac{1}{\overline{T} - h - t_0 + 1} \sum_{t=t_0}^{\overline{T}-h} \left(\widehat{\epsilon}^{k}_{i,t+h} \right)^2 . \tag{19}$$

We assess the multi-step pseudo out-of-sample forecasting performance of Model 2 and Model 3 relative to that of a naïve autoregressive process (Model 1) at any given forecasting horizon h. Our forecast evaluation metric, the relative MSFE, is defined as the ratio of the MSFE of an economic model (either Model 2 or Model 3) relative to the MSFE of the benchmark autoregressive model (Model 1)—i.e., the relative MSFE is given by $rMSFE^{k}_{i,h} \equiv \frac{MSFE^{k}_{i,h}}{MSFE^{1}_{i,h}}$ for any $k = 2, 3$, for each country $i = 1, ..., N$, and for any horizon $h = 1, ..., 12$.

Then, we test if the MSFE of a given economic model (either Model 2 or Model 3) is statistically different from that of the naïve forecast (Model 1). We calculate an F-statistic to test the null hypothesis that the MSFE of the naïve forecasting model (Model 1) is lower than or equal to the MSFE of the competing economic model (either Model 2 or Model 3) against the one-sided alternative that the economic model (either Model 2 or Model 3) outperforms Model 1 achieving a lower MSFE. In other words, we test the null hypothesis that $MSFE_1 \leq MSFE_k$ against the alternative that $MSFE_1 > MSFE_k$ for any economic model $k = 2, 3$. The null can be re-expressed simply as 'the relative MSFE ($rMSFE^{k}_{i,h}$) is greater than or equal to 1.' If the relative MSFE is greater than 1, this indicates that the naïve forecast (Model 1) is more accurate than the

[17] In forecasts where we use filtered series as predictors, we first filter the series—using a 1-sided filter specification—over the full sample period which is split into an estimation and a forecasting subsample for our exercise. We then apply the recursive forecasting scheme described here. Moreover, we should also note that the weights for aggregation are applied before the forecasting procedure and they are kept fixed throughout the recursive scheme.

corresponding economic model (either Model 2 or Model 3)—i.e., $MSFE_{i,h}^{1} \leq MSFE_{i,h}^{k}$ for any $k = 2, 3$.

In all cases, we obtain one-sided tests under the null. Given that all our economic models (Model 2 and Model 3) are nested into the autoregressive specification of Model 1 enables us to use well-established techniques to estimate them as well as to test for the statistical significance of our results. As shown in Clark and McCracken (2005), in nested models the F-statistic for our one-sided hypothesis testing exercise has non-standard, asymptotic distributions and, hence, requires a bootstrap procedure to calculate its corresponding empirical critical values.

The bootstrapping procedure with two-variable regressors was introduced by Clark and McCracken (2005), and we use it in the evaluation of Model 2 against Model 1. To evaluate the relative performance of Model 3 against Model 1, we apply the three-variable extension of the Clark and McCracken (2005) procedure proposed by Kabukçuoğlu and Martínez-García (2016).[18] We calculate critical values based on a simple parametric bootstrap algorithm with 5000 replacements in all cases.

Throughout the paper, we report the MSFE of the benchmark model (Model 1) and the relative MSFEs of a particular economic model (Model 2 or Model 3) against the benchmark model (Model 1). We report the p-values of the F-test at 1%, 5%, and 10% whenever appropriate.

4 Empirical Findings

4.1 *U.S. Inflation Forecasts*

In Tables A1-A2 in the Appendix, we report the forecasting performance of Model 2 and Model 3 (relative to Model 1) with U.S. data. We start with the U.S. because unlike most of the other advanced economies in our sample, the U.S. is still viewed more like a closed-economy for inflation modelling and forecasting. Hence, the U.S. experience allows us to explore the extent to which abstracting from the interconnectedness highlighted by theory actually limits our ability to explain and forecast inflation whenever such abstraction is expected to be of lesser empirical significance. Table A1(a) a and A1(b), report the absolute MSFE of the forecasts based on our benchmark autoregressive process (Model 1) for headline CPI and core CPI inflation, respectively. All remaining entries in Tables A1-A2 report relative MSFEs of Model 2 and Model 3 with respect to this benchmark. We report results for 1, 4, 6, 8, 10, and 12-quarters ahead inflation forecasts. Our main findings can be summarized as follows:

1. In forecasting under Model 2 (see Table A1), we obtain weak or mixed evidence across our two inflation measures for the different explanatory variables that we consider. There is some evidence of

[18] We evaluate the predictivity ability for $h-$quarter ahead inflation for model $k = 3$ and country $i = 1, ..., N$, $\pi_{i,t+h|t}^{3}$, based on rest-of-the-world inflation ($\pi_{i,t}^{*}$) and domestic slack ($y_{i,t}$) as predictors. The procedure of Clark and McCracken (2005) extended by Kabukçuoğlu and Martínez-García (2016) is a parametric bootstrap algorithm that involves the estimation of a 3−equation VAR and uses the residuals to characterize the empirical distribution. The first equation is an autoregressive process for inflation, $\pi_{it} = \beta_1 + \beta_2(L)\pi_{i,t} + e_{it}^{\pi}$, which must hold true under the null that the benchmark model (Model 1) is appropriate to describe the dynamics of inflation. The remaining two equations are the equations for the predictors ($\pi_{i,t}^{*}$ and $y_{i,t}$) where we include the distributed lags of all three variables (including domestic inflation):

$$\pi_{i,t}^{*} = \theta_1 + \theta_{11}(L)\pi_{i,t} + \theta_{12}(L)\pi_{i,t}^{*} + \theta_{13}(L)y_{i,t} + e_{it}^{\pi^*},$$
$$y_{i,t} = \gamma_1 + \gamma_{11}(L)\pi_{i,t} + \gamma_{12}(L)\pi_{i,t}^{*} + \gamma_{13}(L)y_{i,t} + e_{it}^{y}.$$

statistically significant improvements in forecasting accuracy based on global slack using the first-differencing of log real GDP for headline CPI inflation—with aggregation based on equal weights and trade weights. Regarding core CPI inflation forecasts, we find that global slack measures help improve forecasts occasionally. In particular, our IP-based global slack measures tend to exhibit better forecasting performance for core CPI under most weighting schemes. These results are in line with the findings reported by Kabukçuoğlu and Martínez-García (2016) where it is argued that global slack measures in open-economy Phillips curve-based specifications yield mixed results at best. While global slack should efficiently help us predict domestic inflation in theory, imperfect and noisy measures of global slack can potentially deteriorate forecast accuracy in practice. A remedy to this problem based on an alternative specification that relies on global inflation and domestic slack is addressed in the results for Model 3.

2. In forecasting under Model 3 (see Table A2), we consider the role of global inflation and domestic slack from the perspective laid out in equation (18) to analyze the information content of global factors for inflation forecasting. Our domestic slack measures are constructed after 1-sided HP-filtering or log-first-differencing the real GDP or IP data while the rest-of-the-world inflation measures are based on each of the different weighting schemes indicated earlier. This specification provides robust results where the open-economy Phillips curve relationship is shown to outperform the autoregressive benchmark across inflation measures, forecast horizons, weighting schemes, and domestic slack measures. This is a novel finding and one of the key empirical contributions of our study: in the absence of reliable global output gap measures (which can explain the mixed evidence in Table A1), global inflation and domestic slack can help us put together an alternative empirical forecasting specification that is both theoretically-consistent and generally attains improved forecasting accuracy on domestic inflation. Our exercise documents that U.S. inflation dynamics are largely driven by global, rather than solely domestic, changes in real economic activity—and this is clearly reflected in the higher forecast accuracy achieved with Model 3 relative to Model 1.

[Insert Tables A1-A2 About Here]

4.2 Inflation Forecasts Across Advanced Countries

The evidence shown in Tables A1-A2 is particularly striking because it applies to the U.S., which is often regarded as one of the countries least exposed to global developments through trade amongst the advanced economies. Here, we obtain a set of results for a group of 14 advanced economies (including the U.S.) and, in general, our findings across this panel of countries are consistent with the evidence discussed for the U.S. on the accuracy gains of inflation forecasts under Model 2 and Model 3 (Tables A3 and A4):

1. With standard global slack measures (based on IP or real GDP), the performance of Model 2 (Table A3) for inflation forecasting across advanced economies is somewhat weak. First-differenced real GDP seems to yield the most accurate forecasts of headline CPI inflation in the majority of countries, when aggregation is based on equal weighting or trade weights.

2. Model 3 exhibits stronger results for forecasting inflation (Table A4). Theory, as interpreted by Model 3, predicts that the accuracy gains from an open-economy Phillips curve-based model can be fully

attained using a specification that includes a measure of domestic slack and global inflation. For the majority of countries in our sample, we validate this theoretical implication and suggest that inflation in advanced countries appears consistent with the predictions of the workhorse open-economy New Keynesian framework. The result appears to be robust especially at short forecast horizons, which seems natural given that the open-economy Phillips curve itself is viewed as a short-run (not long-run) relationship. There is also a clear pattern emerging across countries where log-first-differencing an output series applied to computing slack seems to yield more accurate forecasts than the 1-sided HP-filtering of the real GDP or IP series. This holds true in spite of the potential measurement error involved in the specification of Model 3 because domestic slack *per se* is not observable.

3. Consistent with theory under a perceived flattening of the Phillips curve slope, we observe that domestic slack in Model 3 generally has only a secondary effect on forecasting while global inflation appears as the dominant factor during the sample period under investigation.

Our results support the theory laid out in the workhorse open-economy New Keynesian model and also highlights the difficulties of forecasting with imperfectly observable macro series and with limited data availability—both issues raised and extensively discussed also in Kabukçuoğlu and Martínez-García (2016). With the forecasting experiments on advanced countries shown in this paper, we conclude that these concerns are valid for advanced countries in general (not just for the U.S.). We propose instead a novel approach to inflation modelling and forecasting epitomized by Model 3 that can overcome some of those major limitations that have plagued the existing literature. We argue that the open-economy Phillips curve-based forecasting model using global inflation and domestic slack seems to find broad-based support in our forecasting exercises across many different countries.

[Insert Tables A3-A4 About Here]

4.3 Robustness Checks

4.3.1 Closed-Economy Phillips Curve-Based Specifications

A conventional closed-economy Phillips curve model can be constructed using domestic slack measures instead of global slack. Model 2 enables us to evaluate the forecasting performance of standard closed-economy Phillips curve regressors if we redefine $y^*_{i,t}$ to be domestic slack (instead of global slack). We can then compare the performance of such closed-economy Phillips curve-based models against Model 1, the benchmark autoregressive process, and indirectly against the open-economy Phillips curve-based specifications (particularly our preferred one, Model 3).

Focusing on the U.S., we find that domestic slack measures obtained by first-differencing log real GDP and log IP show occasionally some value for forecasting core CPI (Table A5). Domestic slack measures obtained with 1-sided HP-filtered real GDP or IP data do not outperform the benchmark autorregressive model (Model 1). These result are essentially consistent with the existing literature, as expected. See, for example, Stock and Watson (2003a). The performance of Model 2 modified to include domestic slack only for inflation forecasting across the 14 advanced economies in our sample is fairly poor (Table A6).

Hence, our evidence confirms the findings of Atkeson and Ohanian (2001) and Stock and Watson (2008), among others, showing that they are pervasive among a wide group of advanced countries. In other words, the lack of forecastability of inflation under a closed-economy Phillips curve-based model specification noted by Atkeson and Ohanian (2001) is not a phenomenon specific to the U.S., but a general pattern that we detect across many different advanced countries. However, on the basis of the results derived from our preferred open-economy Phillips curve-based specification (Model 3), we conclude that the Phillips curve model is still alive and well for inflation modelling and forecasting—albeit not the closed-economy version, but the open-economy specification postulated in this paper.

[Insert Tables A5-A6 About Here]

4.3.2 Global Inflation-Based Specifications

In the spirit of Ciccarelli and Mojon (2010) and Ferroni and Mojon (2014), among others, we consider Model 4 below to forecast domestic inflation with a measure of global inflation alone. The specification is only partly consistent with the forecasting equation in (18) because it ignores the role of domestic slack. While global inflation may be an important factor in forecasting domestic inflation, we know from theory that global inflation alone does not suffice to forecast domestic inflation (as indicated in equation (18)). According to theory, an efficient forecast would requires us to use global inflation and domestic slack.

Therefore, model Model 4 compared to model Model 3 provides us with an indirect assessment of the relative contribution of global inflation against that of the full forecasting model with global inflation and domestic slack. To test the predictive accuracy of global inflation, we introduce a spatio-temporal ADL specification that incorporates not just the effect of those global interdependencies on inflation but also the temporal dimension that helps us better capture empirically the dynamics of domestic inflation, i.e.,

$$\pi^4_{i,t+h|t} = c^4_i + \sum\nolimits_{s=0}^{p} \gamma^4_{i,s}\pi_{i,t-s} + \sum\nolimits_{s=0}^{r} \lambda^4_{i,s}\pi^*_{i,t-s} + \epsilon^4_{i,t+h}, \text{ for country } i \text{ and horizon } h. \qquad \text{(Model 4)}$$

We define $\pi^*_{i,t}$ as the weighted rest-of-the-world inflation, i.e., we define $\pi^*_{i,t}$ as $\sum_{j=1}^{M} w^{\pi}_{ij}\pi_{j,t}$ using the weights w^{π}_{ij}. These weights are specified to capture the interconnectedness between inflation across countries in empirically relevant ways, as we do for Model 3.

The right-hand side of Model 4 augments that of Model 1 with the introduction of rest-of-the-world inflation, $\pi^*_{i,t}$, and its lags, with coefficients $\lambda^4_{i,s}$ for all $s = 0, ..., r$. Needless to say, these are nested models where Model 4 reduces to Model 1 if we set $\lambda^4_{i,s} = 0$ for all $s = 0, ..., r$. As in previous cases, we use the SIC to select the optimal number of lags r of the economic regressor (global inflation), taking as given the lag length p on the dynamics of inflation determined based on the SIC applied to Model 1. Furthermore, if we set $\psi^3_{i,s} = 0$ for all $s = 1, ..., z$ and equate $\lambda^3_{i,s} = \lambda^4_{i,s}$ for all $s = 0, ..., z$ assuming the lag length z in Model 3 equals r, then Model 3 reduces exactly to the specification in Model 4.

In Tables A7-A8, we report our results for the U.S. and for 14 advanced countries (including the U.S.), respectively. We obtain a high performance for forecasting both headline CPI and core CPI inflation under Model 4 with robust findings across all weighting schemes. All results are more accurate than those of the benchmark autoregressive process in Model 1 (with statistical significance at the 10% level and better in most cases). This global-inflation-based specification clearly outperforms Model 1 and it is a lot more successful than Model 2 with global slack or with domestic slack alone.

This result is consistent with the theory derived from the workhorse open-economy New Keynesian model (and the open-economy Phillips curve) that motivates our preferred forecasting specification in

Model 3, particularly whenever $\psi^3_{i,s}$ for $s = 1, ..., z$ are small—which we interpret as possibly arising from a flattened Phillips curve slope. Our results show further evidence that the open-economy Phillips curve-based theory developed earlier can be helpful in practice to address the empirical limitations that arise from data availability and quality problems for measuring slack (global slack in particular) and leads us to more accurately forecasting domestic inflation.

Therefore, we argue that the alternative specification suggested by theory which makes global inflation the centerpiece of the empirical model appears more reliable and useful for forecasting inflation in practice than specifications that rely on poorly-measured global slack (as those included in Model 2). We also argue on the basis of these findings that global inflation is of first-order importance as suggested by the robust results shown for Model 4.

[Insert Tables A7-A8 About Here]

4.3.3 Alternative Modelling Specifications

In forecasting domestic inflation, global inflation and domestic slack are the theoretically-relevant measures under the forecasting equation (18). However, alternative global slack measures like the Kilian (2009) index of global economic activity within the context of Model 2 may capture global interconnectedness in real economic activity along dimensions that remain unmodelled in the workhorse open-economy New Keynesian framework and, therefore, may still prove to be valuable for anyone seeking to more accurately forecast domestic inflation. Other richer empirical specifications that combine complementary information expanding the regressors of Model 3 can also prove useful. Under these premises, we consider a number of related forecasting exercises for robustness:

- Using Model 2, we evaluate the performance of the Kilian (2009) index, as an alternative proxy for the global output gap. As reported in the companion on-line Appendix to this paper, the index produces weak forecasts relative to the benchmark autoregressive in Model 1 for the U.S. and in general across the 14 advanced countries in our sample. In other words, we find this alternative measure to have only a limited value for forecasting within the framework of model Model 2.

- We evaluate inflation forecasts augmenting Model 3 with a broader set of regressors than those suggested by theory to capture unmodelled features and evaluate their predictive accuracy accordingly. We consider models with: (i) global inflation and the Kilian (2009) index, and (ii) global inflation and global slack based on either IP or GDP measures. All these results can be found in the companion on-line Appendix. While the Kilian (2009) index together with global inflation performs well only occasionally in our experiments for the U.S. and the majority of other advanced countries, the model with global inflation and global slack measures yields competitive results compared to our Model 3. In any event, the evidence suggests to us that Model 3 provides a theoretically-grounded and empirically successful forecasting specification which cannot be significantly and systematically improved if we replace domestic slack with a measure of global slack instead.

Finally, we recognize that the slack differential, $\widehat{x}^R_t$, comoves with the terms of trade gap, $\widehat{tot}_t - \widehat{\overline{tot}}_t$, in the workhorse open-economy New Keynesian model—i.e., we recognize that $\widehat{x}^R_t \approx \frac{1}{k}\left(\widehat{tot}_t - \widehat{\overline{tot}}_t\right)$, where k is a composite coefficient of the deep structural parameters of the model (see Martínez-García and Wynne

(2010) for a derivation of this relationship). Hence, the general-form forecasting equation in (17) can alternatively be expressed as,

$$\mathbb{E}_t\left(\widehat{\pi}_{t+h}-\widehat{\pi}_t\right)=-\left(\widehat{\pi}_t^W-\overline{\pi}_t^W\right)-\frac{1}{2}\left(\frac{\Phi\left(\varphi+\gamma\right)}{1-\beta\delta_m}\right)\frac{\kappa^R}{k}\left(\widehat{tot}_t-\widehat{\overline{tot}}_t\right), \tag{20}$$

where $\kappa^R \equiv (2\kappa-1)>0$ is defined as a function of the composite $\kappa \equiv (1-\xi)\left[1-(\sigma\gamma-1)\left(\frac{\gamma}{\varphi+\gamma}\right)\left(\frac{(2\xi)(1-2\xi)}{1+(\sigma\gamma-1)(2\xi)(2(1-\xi))}\right)\right]$. Oil prices are determined in global markets and reflect the balance of global demand and supply—they are often viewed as driving terms of trade movements. Therefore, we consider exploiting the alternative forecasting equation given in (20) using oil price data to proxy for the unobserved terms of trade gap, $\widehat{tot}_t-\widehat{\overline{tot}}_t$. We evaluate inflation forecasts based on: (i) WTI oil prices under the form of Model 2 (i.e., we redefine $y^*_{i,t}$ to capture the WTI oil price series instead of global slack); and (ii) WTI oil prices and global inflation under the form of Model 3 (i.e., where $y_{i,t}$ represents oil prices instead of domestic slack).

- In the forecasts under the proposed reinterpretation of Model 2 (found in the companion on-line Appendix), the 1-sided HP-filtered WTI oil price series does not help yield more accurate forecasts of headline CPI inflation while log-first-differenced WTI oil prices appears to help forecast headline inflation at long horizons more accurately than the benchmark (Model 1). Core CPI inflation, which excludes food and energy, cannot be forecasted more accurately (relative to Model 1) with any of the WTI oil price measures that we consider here.

- Under the reinterpretation of Model 3, the most accurate forecasts of headline CPI inflation are those we obtain with a combination of global inflation and WTI oil prices (particularly after log-first-differencing the series). These results appear to be true for the majority of the advanced countries studied in this paper (as seen in the results reported in the companion on-line Appendix). Once again, our findings support the inflation model favored in this paper based on the open-economy Phillips curve with global inflation and domestic slack.

4.4 A Summary of the Key Results

After reviewing all our findings, our conclusion is that Model 4 works quite well empirically—with high forecast accuracy and robust results across different aggregation schemes. Global inflation helps forecast both headline and core CPI inflation and generally performs similar to Model 3 and much better than Model 2. The performance of the theoretically-consistent specification under Model 3 is comparable to that of Model 4. We must recognize that imperfect measures of domestic and global slack introduce an additional source of noise in our inflation forecasts that may lead to a deterioration in forecasting accuracy for Model 3 and perhaps more so for Model 2. In spite of that, our results are broadly supportive of the theory laid out by the workhorse open-economy New Keynesian model. Hence, we interpret the performance of Model 3 and Model 4 as suggestive that most of the gains achieved in forecasting accuracy should be attributed primarily to the contribution of global inflation—which is what we would expect whenever the Phillips curve slope is fairly flat, a plausible scenario for many of the advanced countries in our sample and for our sample period.

Model 4 performs similarly to the theoretically-consistent Model 3, but global inflation alone misses the important linkages that theory highlights—which require incorporating domestic slack. This suggests that, perhaps, the benchmark to beat in future research on inflation forecasting may very well look more like Model 3 than Model 1. In fact, our results confirm that global inflation alone is a major factor contributing to improved forecasting accuracy across many different horizons and country experiences (as noted also in Ciccarelli and Mojon (2010), Ferroni and Mojon (2014), and Duncan and Martínez-García (2015), among others). Hence, even Model 4 could be a tougher yardstick for judging whether an economic model for forecasting adds value or not going forward than the naïve autoregressive benchmark (Model 1).

We show, in general, that using equal weights performs better than using alternative weighting schemes to capture the international interactions suggested by the model. Whenever the interactions are complex and not fully known or understood, a simple matrix of equal weights may be the best aggregation scheme at our disposal (working consistently well for different countries and forecasting horizons). Our findings complement those of Stock and Watson (2004) and D'Agostino and Surico (2009) showing that, indeed, equal weights do quite well across a variety of forecasting models, forecasting variables and horizons, and country experiences. It is simple and robust across a great deal of heterogeneous forecasting models and, accordingly, quite useful for forecasting in practice. Nonetheless, it is worth noting that trade-based measures show similar results too.

Our empirical findings also confirm that conventional measures of domestic or global slack do not help improve our forecasts of domestic inflation. We show that this is a stylized fact in the U.S. and for many other advanced countries. Log-first-differenced WTI oil prices together with global inflation in Model 3 is closest to Model 4 in terms of forecast performance for headline CPI inflation. Some domestic slack measures together with global inflation appear competitive when forecasting both headline and core CPI inflation. These results hold for the U.S. as well as for a large number of other advanced countries.

We believe that our results also highlight the difficulties of modelling and forecasting inflation with imperfectly observable macro series and limited data—both issues are extensively discussed in Martínez-García and Wynne (2010) and Kabukçuoğlu and Martínez-García (2016). Our paper suggests a new approach to partly overcome some of the limitations that have plagued the existing literature: an open-economy Phillips curve can be expressed in terms of global inflation and domestic slack (Model 3) to successfully forecast inflation across a variety of advanced countries (including the U.S.). The empirical findings of the paper broadly support this specification based on the open-economy Phillips curve.

Finally, a word of caution on the value of domestic slack as an economic regressor in Model 3. It is difficult to quantify how our forecasts might be affected by the measurement error we introduce when using a statistically-filtered series in place of the unobserved domestic slack. The terms of trade gap can also be a useful explanatory variable in conjunction with global inflation for forecasting domestic inflation, but suffer of the same concern since it is also unobservable. The measurement errors associated with approximating unobserved data using statistically-filtered data can be a problem for the resulting forecast accuracy of Model 3. Hence, although our findings are broadly positive, we expect that further improvement can be achieved with more tightly estimated measures of domestic slack.

4.4.1 What Does Domestic Slack Add?

We further investigate the in-sample performance of domestic slack in Model 3 as an explanatory variable for domestic inflation. In particular, we aim to understand to what extent the domestic output gap, despite the well-known measurement issues to which we alluded before, improves inflation predictions over a simpler model with global inflation alone (Model 4). To isolate the effect of domestic slack in predicting inflation, we consider specifications of Model 3 which are nested into Model 4. We evaluate the in-sample predictive accuracy of these two competing models based on OLS estimates over the 1984:Q1-2015:Q1 period, predicting inflation in 14 advanced countries (including the U.S.) and constructing rest-of-the-world inflation measures from the same pool of countries as in our forecasting exercise.

To ensure that Model 4 is nested into Model 3, we first select the lag length of the rest-of-the-world inflation aggregate in Model 4 based on the SIC, and then use this lag length for rest-of-the-world inflation in Model 3 as well. Then, we determine the lag length of domestic output gap in Model 3 according to the SIC. We retain in both cases the lag length for domestic inflation obtained from Model 1 according to the SIC. The maximum lag length allowed for each variable is four.

Our metrics of in-sample fit accuracy for a given model are based on the mean squared error (MSE) and the SIC. A relative MSE, calculated as MSE3/MSE4, that is less than 1 tends to favor Model 3 over Model 4. An SIC difference, SIC3-SIC4, that is less than 0 similarly suggests that Model 3 is preferred by the data over Model 4 even after penalizing for model overfitting. By construction, the SIC imposes a penalty for more complex models (models that are more heavily parameterized). Therefore, the SIC imposes a higher threshold to pass for Model 3 relative to Model 4, as there are a number of additional coefficients in Model 3 introduced with the additional explanatory variable of the model (domestic slack).

We report the results for the in-sample predictive performances of the two models for U.S. CPI and core CPI inflation in the companion on-line Appendix. Except for the two cases where the dependent variable is headline CPI inflation and the output gap measures are based on log-first-differenced series for IP and real GDP, our MSE and SIC findings for the U.S. tend to provide limited support for Model 3 in-sample. In general, our results are mixed and do not show significant differences between Model 3 and Model 4 given how the relative MSE and SIC are very close to 1 and 0, respectively.

In Table A9, we summarize the results from our sample of 14 advanced countries by reporting the fraction of countries with relative MSE and SIC differences less than 1 and 0, respectively. This empirical evidence broadly favors Model 3 over Model 4 for the majority of countries under different output gap measures and weighting schemes, based on the relative MSE metric. SIC differences of Model 3 relative Model 4 provide weaker support for some countries, yielding a more nuanced picture.

The SIC penalizes overfitting unlike the MSE statistic. Hence, our results suggest that Model 3 is generally favored by the cross-country data to explain domestic inflation in-sample, at the expense of adding additional parameters over the more parsimonious specification of Model 4. Yet, when we take account of the different parameterization by penalizing overfitting, the results are less robust in favor of Model 3 because the gains in in-sample fit achieved by Model 3 come at the cost of adding more parameters. We argue that modeling parsimony is an important criterion in empirical work, but theory does not demand it. However, the broad evidence of improved in-sample performance favoring Model 3 under MSE is consistent with what we expect from theory.[19]

[19] In related work, Clark and McCracken (2006) study the apparent disconnect between good in-sample fit and poor out-of-sample forecasting performance of Phillips-curve-based models (albeit conventional ones implied by the closed-economy specification). These authors argue that in part the weakness of the out-of-sample performance can be attributed to power limitations of the standard metrics used, but that instabilities in the coefficients of the output gap play an important role too. We argue that this latter point is related to globalization and can be partly addressed switching to the open-economy Phillips curve modelling framework instead—an issue extensively discussed in Kabukçuoğlu and Martínez-García (2016). In here, we show that the global slack measures used with the open-economy Phillips curve model are rather noisy but, alternatively, that global inflation together with domestic slack provide the same information content for inflation forecasting and a much more robust signal. This, in turn, results in both good in-sample fit

If the coefficient of the domestic output gap under Model 3 is small, then it would be natural—according to theory—to observe similar predictive performances under Model 3 and Model 4. We follow Stock and Watson (2003b) and aggregate the OLS coefficient estimates for the lags of domestic output gap in Model 3 in order to map them into a measure of persistence. The inverse of one minus this sum of coefficients, referred to as the persistence, is higher if the sum of the estimated coefficient estimates is higher. The companion on-line Appendix reports the ranges and the median values for domestic output gap persistence calculated in this way, across various model specifications, inflation measures, and countries.

To interpret these results based on the estimated OLS coefficients in connection with our metrics of in-sample accuracy, we present a scatter plot in Figure A1 where we illustrate, for each country in our sample, the relationship between the median of the relative MSE (or median SIC difference) of Model 3 versus Model 4 and this measure of domestic output gap persistence. All possible specifications under consideration for each country are summarized with the median. The scatter plots suggest that higher persistence (which means a higher sum of the OLS-estimated coefficients) is associated with stronger empirical support for Model 3 (both under the SIC and MSE metrics). This result is consistent with the theoretical implication of the workhorse New Keynesian model which suggests that the flattening of the Phillips curve (associated with a lower coefficient on domestic slack) is an important reason explaining the dominant role played by global inflation in Model 3.

[Insert Tables A9 and Figure A1 About Here]

Finally, we should also note that a parsimonious model like Model 4 which relies solely on cross-country inflation data is generally less subject to revisions, issues with publication lags, etc., than specifications like Model 3 that also use output (IP, real GDP) data. In this sense, Model 3 improves over the open-economy Phillips curve specification based on global slack (given by Model 2) but still relies to a certain extent on domestic slack—and domestic slack is a noisy measure which can impact the model's forecasting accuracy. Nonetheless, domestic slack in Model 3 poses less of a concern than global slack in Model 2 because data limitations are less severe in this case (for example, publication lags across macro time series tend to be smaller within a country than across countries, data coverage is often better, etc.). In turn, global inflation is constructed with CPI data alone which is less subject to revisions, tends to be more easily available (particularly headline), and it is released more frequently (generally at monthly frequency) and with shorter publication lags than the output data needed to construct either domestic or global slack. Publication lags, data revisions, data quality issues, etc., can potentially result in a downward impact on forecasting accuracy and so, in our view, the better data available on inflation explains in part the competitive performance shown and practical advantage of a simpler like that of Model 4 which relies on global inflation alone (excluding the noisier domestic slack from Model 3).

5 Concluding Remarks

The seminal work of Atkeson and Ohanian (2001) and Stock and Watson (2008) documented a break in the inflation forecasting performance of the closed-economy Phillips curve during the Great Moderation. The economic relationship between domestic inflation and domestic economic activity no longer seemed

and strong forecasting performance pseudo out-of-sample of Model 3 in our empirical analysis.

to work as a tool for inflation forecasting. Declining forecasting accuracy can be an issue not only with reduced-form forecasting models of inflation, but also with the sort of DSGE models which have become commonplace for policy analysis and forecasting (as indicated by Edge and Gürkaynak (2010)). In this paper, we show in turn that the Phillips curve is alive and well for forecasting, after all—so long as one considers an open-economy Phillips curve specification rather than the standard closed-economy one that has been prevalent in much of the literature.

The major contribution of our paper is to show that fully incorporating the international trade linkages of an economy with respect to the rest of the world is important—in theory and in practice—to explain the dynamics of inflation and to improve the forecasting accuracy of open-economy Phillips curve-based models. Our interpretation of how global interconnectedness matters for domestic inflation is linked to global inflation through the lens of the workhorse open-economy New Keynesian model—and, to our knowledge, this theoretical nexus is not something that has been explored before in the literature.

Our empirical analysis using tests of forecasting accuracy reveals the importance of modelling the richer spatio-temporal dynamics of inflation. The evidence provided in the paper indicates that specifying the forecasting model appropriately in order to recognize empirically the dynamics over time of the data and the complexity of linkages across countries—especially in regards to the inflation variable itself—is crucial to improve our inflation forecasts across many advanced economies and even for the U.S.

The literature studying inflation modelling and forecasting, in particular for the U.S., has acknowledged the role of global economic conditions in understanding domestic inflation only recently (even though globalization itself is not a recent phenomenon). The big-picture implication of our findings points toward the increasing importance of global macroeconomic forces in explaining and predicting domestic inflation. The novelty of our approach arises from merging both theory and applied work to highlight such connections and the practical application of those insights for inflation forecasting and policymaking. Our novel empirical results on forecasting complemented with evidence of goodness-of-fit in-sample are consistent with the view that global forces must be taken into account in order to effectively understand the dynamics of domestic inflation in open-economies.

We also show that the weighting choice is important to capture the international linkages in the data. In our opinion, alternative weighting schemes that incorporate the extent of those linkages more fully may be a fruitful avenue of future research. We considered different measures that are fairly standard to proxy the extent to which different countries are interconnected and we have also considered other variables to proxy for trade costs or "proximity" across countries (distance), etc. However, none of them generally does consistently better than using equal weights—albeit performance based on trade weights is quite competitive. Hence, more research may be needed on the optimal selection of weights for forecasting.

Our final point reiterates that a successful model to forecast domestic inflation can be improved by modelling the international linkages of the domestic economy through global inflation and domestic slack. We argue that the class of global-inflation-based models which have been gaining some notoriety in the literature (see, e.g., Ciccarelli and Mojon (2010), Ferroni and Mojon (2014)) are a step in the right direction. Therefore, a theoretical specification such as the one proposed in this paper incorporating global inflation can become over time the benchmark to beat in inflation forecasting. We also point out that, according to theory, global-inflation-based models can be rather successful even abstracting from other economic regressors (like domestic slack) whenever the slope of the Phillips curve is fairly flat, as this makes the contribution of global inflation of first-order importance for explaining and forecasting domestic inflation.

Appendix

A Data Description

This section gives details for the data used in the paper.

Abbreviations

BLS = U.S. Bureau of Labor Statistics; BEA = Bureau of Economic Analysis; DGEI = Database of Global Economic Indicators (Federal Reserve Bank of Dallas); IMF = International Monetary Fund; SA = Seasonally adjusted. All series are quarterly unless indicated otherwise.

1 **Inflation measures**

We use series staring in 1984:Q1 and ending in 2015:Q1 (SA, 2010=100). CPI (all items) is available from the Bureau of Labor Statistics (BLS) for the U.S. going back to 1947:Q1, while core CPI (all items ex. food and energy) is available from the BLS going back to 1957:Q1. We use headline and core inflation series comparable with those of the U.S. for all 14 advanced economies in our sample—obtained from the database of global economic indicators (DGEI) of the Federal Reserve Bank of Dallas (see the details in Grossman et al. (2014)).

2 **Global slack and global inflation measures**

The series for the individual countries needed to construct global slack and rest of the world inflation measures are obtained from the Federal Reserve Bank of Dallas' DGEI (see the details in Grossman et al. (2014)). Weighted averages of filtered quarterly Industrial Production and real GDP series (using either first-differencing in logs expressed in percentages or a 1-sided Hodrick-Prescott-filter also in logs and expressed in percentages) for the period 1984:Q1-2015:Q1 are used as proxy measures for unobservable global slack.[20] Annualized log differences of quarterly headline CPI and core CPI series in percentages are used in constructing the rest of the world inflation measures. Country coverage varies with data availability. The list of countries used in each sample is given below.

Table A1 Panels (c) and (g): Australia, Austria, Belgium, Canada, Chile, France, Germany, Greece, Hungary, India, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Portugal, South Africa, Spain, Sweden, Switzerland, Taiwan, United States, United Kingdom.

Table A1 Panels (d) and (h): Australia, Austria, Belgium, Canada, Chile, France, Germany, Italy, Japan, Korea, Mexico, Spain, Sweden, Switzerland, Taiwan, United States, United Kingdom.

Table A1 Panels (e) and (i): Australia, Austria, Belgium, Canada, China, Colombia, France, Germany, Indonesia, Italy, Japan, Korea, Mexico, Netherlands, Philippines, Portugal, South Africa, Spain, Sweden, Switzerland, Taiwan, United States, United Kingdom.

Table A1 Panels (f) and (j): Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Mexico, Netherlands, Spain, Sweden, Switzerland, United States, United Kingdom.

Table A2 Panels (a) and (e): Australia, Austria, Belgium, Canada, Chile, France, Germany, Greece, Hungary, India, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Portugal, South Africa, Spain, Sweden, Switzerland, Taiwan, United States, United Kingdom.

[20] The H-P filter is applied as described in Stock and Watson (1999). This is a one-sided HP filter.

Table A2 Panels (b) and (f): Australia, Austria, Belgium, Canada, Chile, France, Germany, Italy, Japan, Korea, Mexico, Spain, Sweden, Switzerland, Taiwan, United States, United Kingdom.

Table A2 Panels (c) and (g): Australia, Austria, Belgium, Canada, China, Colombia, France, Germany, Indonesia, Italy, Japan, Korea, Mexico, Netherlands, Philippines, Portugal, South Africa, Spain, Sweden, Switzerland, Taiwan, United States, United Kingdom.

Table A2 Panels (d) and (h): Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Mexico, Netherlands, Spain, Sweden, Switzerland, United States, United Kingdom.

Table A5 Panel (a): Australia, Austria, Belgium, Canada, Chile, France, Germany, Greece, Hungary, India, Italy, Japan, Korea, Malaysia, Mexico, Netherlands, Portugal, South Africa, Spain, Sweden, Switzerland, Taiwan, United States, United Kingdom.

Table A5 Panel (b): Australia, Austria, Belgium, Canada, Chile, France, Germany, Italy, Japan, Korea, Mexico, Spain, Sweden, Switzerland, Taiwan, United States, United Kingdom.

The same pool of countries (switching the U.S.) is employed for all other 13 advanced countries in our sample for which we perform our analysis.

3 Kilian (2009)'s index of global economic conditions

Kilian (2009)'s index of global economic conditions is based on monthly series of dry cargo single voyage ocean freight rates. The series covers the period 1968:M1 till 2015:M1 and can be accessed at: http://www-personal.umich.edu/~lkilian/reaupdate.txt. The quarterly series that we use is averaged across the three months of each quarter.

4 Oil prices

West Texas Intermediate Crude Oil 40 Deg. Beginning of Month ($/BBL), quarterly series obtained by averaging monthly series available for the period 1947:Q1-2015:Q1 obtained from the FRED database (FRED codes: MCOILWTICO and OILPRICE) (SA, 2005=100).

5 Country weights

The weights for any country i out of the N for which we conduct our empirical analysis which corresponds to a sample of 14 advanced economies (Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and United States) are defined as w_{ij}^{y}, for all $j = 1, ..., M$, where M corresponds to a sample of up to 29 countries for which we can draw data.[21] The weights for rest-of-the-world inflation are consistent for all entries except for the home country (intra-national weights are netted out).[22] Weighted aggregates for inflation have the home country weight set to 0, by construction. In other words, for country i, we consider rest-of-the-world inflation weights w_{ij}^{π} which set a country's own weight equal to zero (i.e., $w_{ii}^{\pi} = 0$) while other weights are re-scaled accordingly so they still sum up to 1 (i.e., $w_{ij}^{\pi} = \frac{w_{ij}^{y}}{1-w_{ii}^{y}}$ for any $j \neq i$). We use 5 measures of country weights in order to compute our global slack and rest-of-the-world inflation measures:

[21] This set of $M = 29$ countries used to construct our global measures naturally includes the 14 advanced countries that we investigate in the paper.

[22] A country's own weight is non-zero in all weighting schemes except for the contiguity measure since, by definition, a country does not have a border with itself.

W1 Equal weights for country i (for any $i = 1, ..., N$): The weights are given by $w^y_{ij} = \frac{1}{M}$, for all $j = 1, ..., M$, where M is the number of countries in the sample including the domestic economy.

W2 Contiguity weights for country i (for any $i = 1, ..., N$): The weights w^y_{ij} equal $\frac{1}{Z}$ if the home country i and country j share a border and 0 otherwise, for all $j = 1, ..., M$. Here, Z is given as the total number of countries that share a border with the home country.

W3 Distance weights for country i (for any $i = 1, ..., N$): These weights are based on geodesic distances that are calculated following the great circle formula, which uses latitudes and longitudes of the most important cities/agglomerations (adjusted by population size). The *dist* variable is obtained from the GeoDist dataset.[23] In particular, we use the inverse of the square of the bilateral distances between the home country i and country j, $\frac{1}{dist^2_{ij}}$, and construct the weights to be normalized to sum up to 1 as follows $w^y_{ij} \equiv \frac{\frac{1}{dist^2_{ij}}}{\sum_{j=1}^{M} \frac{1}{dist^2_{ij}}}$ for all $j = 1, ..., M$.

W4 Population-adjusted distance weights for country i (for any $i = 1, ..., N$): These weights are constructed using the *distwces* measure from the GeoDist dataset, based on city-level data to obtain the geographic distribution of population (in 2004) inside each country. The bilateral distances between the biggest cities of the two countries are calculated and the inter-city distances are weighted by the share of the city in the overall country's population. As with the distance-based weights proposed before, we use the inverse of the square of the population-adjusted distance between the home country i and country j, $\frac{1}{distwces^2_{ij}}$, and construct the weights to be normalized to sum up to 1 as follows $w^y_{ij} \equiv \frac{\frac{1}{distwces^2_{ij}}}{\sum_{j=1}^{M} \frac{1}{distwces^2_{ij}}}$ for all $j = 1, ..., M$.

W5 Trade weights for country i (for any $i = 1, ..., N$): To construct the trade weights we use annual IMF Direction of Trade (DOT) data for every country $j = 1, ..., M$ on their merchandise nominal imports from the world, imp_j, and their merchandise nominal exports to the world, exp_j, obtained through the Federal Reserve Bank of Dallas' DGEI (see the details in Grossman et al. (2014)).[24] With those two series, we construct trade weights for any home country i as follows: $w^y_{ij} \equiv \frac{\text{imp}_j + \text{exp}_j}{\sum_{i=1}^{M} \text{imp}_j + \text{exp}_j}$ for all $j = 1, ..., M$. These weights are based only on each country's share in world trade and do not reflect the actual bilateral trade linkages between country i and j—hence, these weights only account for how open each country is relative to the rest of the world through trade. The weights obtained with this formula are the same for any country i (i.e., w^y_{ij}). The annual IMF DOT data is available for the entire $1980 - 2014$ period. We use here trade weights constructed with the average of the full $1984 - 2014$ period.

B Figures and Tables

[23] For a detailed explanation of the GeoDist data, see Mayer and Zignago (2011). The GeoDist database can be accessed at http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6

[24] The series for imports and exports are expressed in U.S. dollars for all countries.

Forecasts of U.S. Inflation - Relative MSFEs (1997:Q1-2015:Q1)												
Horizon	**1**	**4**	**6**	**8**	**10**	**12**	**1**	**4**	**6**	**8**	**10**	**12**
			CPI						**Core CPI (CPI ex. Food & Energy)**			
Model 1	(a)						(b)					
Autoregressive	5.445	2.035	1.354	1.119	0.991	0.905	0.313	0.296	0.292	0.304	0.316	0.305
Model 2 against Model 1												
Global slack (IP-HP)	(c)						(d)					
Equal weights	1.009	0.974	1.017	1.067	1.095	1.151	1.028	0.831^{***}	0.817^{**}	0.930^{*}	1.121	1.452
Contiguity	1.018	1.058	1.144	1.175	1.153	1.162	0.979^{*}	0.852^{**}	0.872^{**}	0.911^{*}	0.942	1.016
Distance	1.008	1.023	1.053	1.057	1.061	1.066	0.961^{**}	0.803^{**}	0.790^{**}	0.834^{**}	0.910^{**}	0.993
Pop. weighted distance	1.012	1.027	1.065	1.091	1.103	1.121	0.982^{*}	0.835^{**}	0.816^{**}	0.873^{*}	1.018	1.268
Trade weights (1984-2014)	1.026	0.985	1.039	1.104	1.141	1.210	1.034	0.828^{*}	0.819^{*}	0.935^{*}	1.136	1.549
Global slack (GDP-HP)	(e)						(f)					
Equal weights	0.985^{*}	0.953^{*}	1.182	1.120	1.173	1.211	1.006	0.909^{**}	1.009	1.188	1.417	1.846
Contiguity	1.017	1.058	1.138	1.158	1.132	1.177	1.001	0.946^{*}	1.008	1.043	1.050	1.123
Distance	1.007	1.015	1.038	1.034	1.037	1.058	0.983^{*}	0.891^{**}	0.910^{*}	0.988	1.093	1.205
Pop. weighted distance	1.003	1.011	1.054	1.070	1.073	1.094	0.972^{*}	0.809^{**}	0.778^{**}	0.888^{*}	1.056	1.236
Trade weights (1984-2014)	1.003	0.972	1.033	1.125	1.174	1.224	1.004	0.873^{**}	0.947	1.131	1.377	1.810
Global slack (IP-FD)	(g)						(h)					
Equal weights	1.034	1.039	1.007	1.047	1.105	1.129	1.056	1.102	1.003	0.996	1.124	1.240
Contiguity	1.009	1.037	1.055	1.053	1.052	1.032	1.022	0.951^{*}	0.916^{**}	0.934^{*}	0.935^{*}	0.938^{*}
Distance	1.009	1.030	1.031	1.032	1.025	1.031	1.068	0.913^{**}	0.822^{***}	0.827^{***}	0.871^{**}	0.920^{**}
Pop. weighted distance	1.050	1.049	1.057	1.074	1.061	1.066	1.051	0.953^{*}	0.862^{**}	0.846^{**}	0.879^{**}	0.919^{*}
Trade weights (1984-2014)	1.096	1.092	1.019	1.070	1.139	1.168	1.098	1.175	1.066	1.060	1.213	1.389
Global slack (GDP-FD)	(i)						(j)					
Equal weights	0.960^{**}	0.929^{**}	0.905^{**}	1.026	1.096	1.106	1.141	1.088	1.007	1.066	1.269	1.543
Contiguity	1.007	1.017	1.028	1.020	1.008	1.001	1.018	0.955^{*}	0.927^{**}	0.944^{*}	0.951^{*}	0.963^{*}
Distance	1.002	1.009	1.003	1.005	1.019	1.043	1.085	0.978	0.888^{**}	0.914^{**}	0.985	1.078
Pop. weighted distance	0.991	0.987	0.967^{*}	0.978	0.979	0.978	1.008	0.931^{**}	0.831^{***}	0.833^{***}	0.876^{**}	0.929^{**}
Trade weights (1984-2014)	0.986^{*}	0.955^{*}	0.891^{**}	0.983	1.059	1.074	1.136	1.100	0.966	1.026	1.257	1.509

TABLE A1

Note: This table reports the forecasting performance with an estimation sample covering 1984:Q1-1996:Q4 and a pseudo out-of-sample forecasting sample over 1997:Q1-2015:Q1. We distinguish global slack based on whether we use the one-sided Hodrick-Prescott (HP) filter or first-differencing (FD) for filtering the data. We construct alternative measures of global slack based on industrial production (IP) and real GDP (GDP) data. In Model 1, we report the MSFE of forecasts with a simple univariate autoregressive process of inflation (our benchmark model), and it is therefore in absolute terms. The remaining entries in this table are the MSFE of the forecasts under different variants of Model 2 relative to the MSFE of the benchmark Model 1. Asterisks denote that the MSFE of the corresponding variant of Model 2 is statistically different and more accurate than the MSFE of the benchmark Model 1 at 1 (***), 5 (**), and 10 (*) percent significance levels.

Forecasts of U.S. Inflation - Relative MSFEs (1997:Q1-2015:Q1)												
Horizon	**1**	**4**	**6**	**8**	**10**	**12**	**1**	**4**	**6**	**8**	**10**	**12**
	CPI						**Core CPI (CPI ex. Food & Energy)**					
Model 3 against Model 1												
Domestic slack (IP-HP)												
& Global inflation	(a)						(b)					
Equal weights	0.566***	0.774***	0.842**	0.843**	0.889**	1.061	0.910***	0.701***	0.677**	0.678**	0.685**	0.726**
Contiguity	0.992	0.935*	0.886*	0.834**	0.749**	0.616**	0.968*	0.803**	0.764**	0.752**	0.738**	0.735**
Distance	0.766***	0.775***	0.732***	0.709***	0.692***	0.641***	0.940**	0.738***	0.658***	0.630***	0.636***	0.676**
Pop. weighted distance	0.971*	0.905**	0.850**	0.894**	0.711**	0.780***	0.963**	0.793**	0.751**	0.737**	0.718**	0.710**
Trade weights (1984-2014)	0.768***	0.797***	0.832**	0.821**	0.814**	0.841**	0.893***	0.711***	0.716**	0.741**	0.780**	0.882*
Domestic slack (GDP-HP)												
& Global inflation	(c)						(d)					
Equal weights	0.879***	0.855**	0.859**	0.799**	0.735**	0.684**	0.910***	0.701***	0.677**	0.678**	0.685**	0.726**
Contiguity	0.983*	0.916*	0.863*	0.809**	0.728**	0.611**	0.968*	0.803**	0.764**	0.752**	0.738**	0.735**
Distance	0.760***	0.756***	0.706***	0.668***	0.628***	0.571***	0.940**	0.738***	0.658***	0.630**	0.636	0.676
Pop. weighted distance	0.963**	0.884***	0.824**	0.765**	0.681**	0.562***	0.963*	0.793***	0.751***	0.737**	0.718	0.710
Trade weights (1984-2014)	0.785***	0.786***	0.821**	0.797**	0.764**	0.696**	0.893***	0.711***	0.716***	0.741**	0.780*	0.882
Domestic slack (IP-FD)												
& Global inflation	(e)						(f)					
Equal weights	0.596***	0.787***	0.825**	0.789**	0.731**	0.714**	0.953**	0.776**	0.713**	0.683**	0.634**	0.557**
Contiguity	1.037	0.963*	0.902*	0.853**	0.742**	0.606***	1.022	0.896**	0.818**	0.782**	0.742**	0.668**
Distance	0.796***	0.797***	0.729***	0.697***	0.652***	0.595***	0.997*	0.856**	0.723***	0.651**	0.625**	0.611**
Pop. weighted distance	1.014	0.932*	0.865**	0.811**	0.702**	0.565**	1.016	0.885**	0.803**	0.763**	0.721**	0.648**
Trade weights (1984-2014)	0.791**	0.806**	0.816**	0.781**	0.706**	0.646**	0.933**	0.773**	0.726**	0.707**	0.660**	0.591**
Domestic slack (GDP-FD)												
& Global inflation	(g)						(h)					
Equal weights	0.884**	0.871**	0.849**	0.782**	0.699**	0.629**	0.941**	0.782***	0.680**	0.644**	0.609**	0.554**
Contiguity	0.980*	0.913**	0.827**	0.772**	0.692**	0.573***	0.987	0.864**	0.753**	0.720**	0.707**	0.682**
Distance	0.762***	0.766***	0.682***	0.637***	0.588***	0.530***	0.969**	0.836***	0.692***	0.621***	0.594***	0.588***
Pop. weighted distance	0.961**	0.885**	0.794**	0.733**	0.649***	0.529***	0.983*	0.853**	0.742**	0.706**	0.688**	0.662**
Trade weights (1984-2014)	0.790***	0.800***	0.807**	0.775**	0.728**	0.653***	0.922***	0.755***	0.663***	0.634***	0.590***	0.530***

TABLE A2

Note: This table reports the forecasting performance with an estimation sample covering 1984:Q1-1996:Q4 and a pseudo out-of-sample forecasting sample over 1997:Q1-2015:Q1. We distinguish domestic slack based on whether we use the one-sided Hodrick-Prescott (HP) filter or first-differencing (FD) for filtering the data. We construct alternative measures of domestic slack based on industrial production (IP) and real GDP (GDP) data. The entries in this table are the MSFE of the forecasts under different variants of Model 3 relative to the MSFE of the benchmark Model 1. Asterisks denote that the MSFE of the corresponding variant of Model 3 is statistically different and more accurate than the MSFE of the benchmark Model 1 at 1 (***), 5 (**), and 10 (*) percent significance levels.

Inflation Forecast Performance in Advanced Countries

Horizon	1	4	6	8	10	12	1	4	6	8	10	12
			CPI						Core CPI (CPI ex. Food & Energy)			
Model 2 against Model 1												
Global slack (IP-HP)												
Equal weights	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Contiguity*	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)
Distance	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Pop. weighted distance	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Trade weights (1984-2014)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Global slack (GDP-HP)												
Equal weights	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Contiguity*	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Distance	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Pop. weighted distance	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Trade weights (1984-2014)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Global slack (IP-FD)												
Equal weights	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Contiguity*	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)
Distance	[0,0.25)	[0.25,0.5)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0,0.25)
Pop. weighted distance	[0,0.25)	[0.25,0.5)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0,0.25)
Trade weights (1984-2014)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Global slack (GDP-FD)												
Equal weights	[0.5,0.75)	[0.25,0.5)	[0.25,0.5)	[0,0.25)	[0,0.25)	[0,0.25)	[0.25,0.5)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)
Contiguity*	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0,0.25)	[0,0.25)	[0,0.25)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0,0.25)
Distance	[0.25,0.5)	[0.25,0.5)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0,0.25)
Pop. weighted distance	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)	[0.25,0.5)
Trade weights (1984-2014)	[0.5,0.75)	[0.25,0.5)	[0.25,0.5)	[0,0.25)	[0,0.25)	[0,0.25)	[0.25,0.5)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)	[0,0.25)

Color legend: [0.75,1] [0.5,0.75) [0.25,0.5) [0,0.25)

TABLE A3

Note: This table summarizes the forecasting performance for a sample of 14 countries which includes: Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and United States. The estimation sample covers the period 1984:Q1-1996:Q4 with a pseudo out-of-sample forecasting sample over 1997:Q1-2015:Q1. We distinguish global slack based on whether we use the one-sided Hodrick-Prescott (HP) filter or first-differencing (FD) for filtering the data. We construct alternative measures of global slack based on industrial production (IP) and real GDP (GDP) data. The entries in this table represent the fraction of countries out of the 14 for which we have data where we find that the MSFE of each forecasting model (a variant of Model 2) is statistically different and more accurate than the MSFE of the country's benchmark model (Model 1) at least at the 10 percent significance level. Specific country results are available from the authors upon request.
(*)The results for the contiguity measure are reported for 10 countries only (Australia, Japan, Sweden, and United Kingdom were omitted).

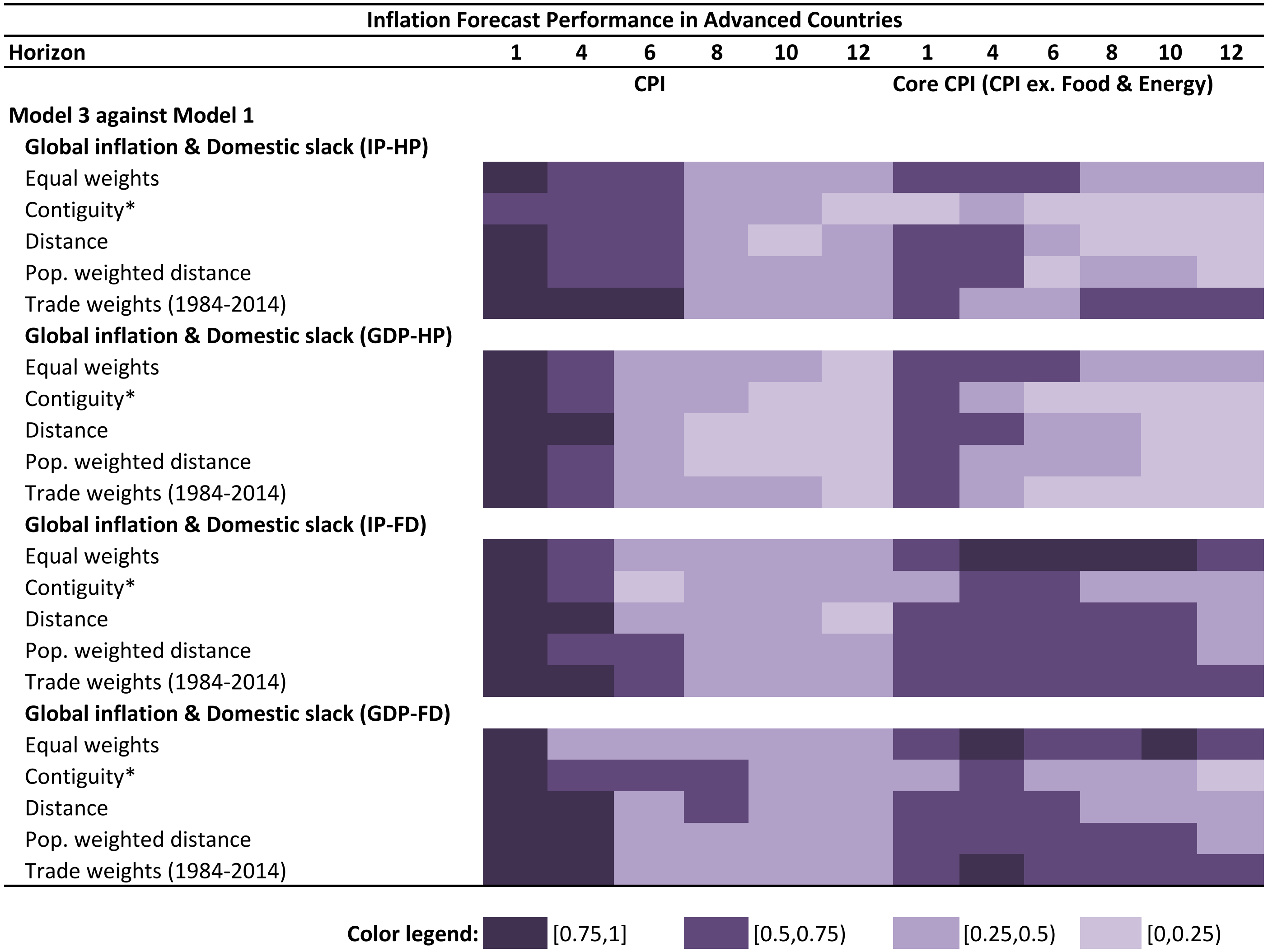

TABLE A4

Note: This table summarizes the forecasting performance for a sample of 14 countries which includes: Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and United States. The estimation sample covers the period 1984:Q1-1996:Q4 with a pseudo out-of-sample forecasting sample over 1997:Q1-2015:Q1. We distinguish domestic slack based on whether we use the one-sided Hodrick-Prescott (HP) filter or first-differencing (FD) for filtering the data. We construct alternative measures of domestic slack based on industrial production (IP) and real GDP (GDP) data. The entries in this table represent the fraction of countries out of the 14 for which we have data where we find that the MSFE of each forecasting model (a variant of Model 3) is statistically different and more accurate than the MSFE of the country's benchmark model (Model 1) at least at the 10 percent significance level. Specific country results are available from the authors upon request.
(*)The results for the contiguity measure are reported for 10 countries only (Australia, Japan, Sweden, and United Kingdom were omitted).

Forecasts of U.S. Inflation - Relative MSFEs (1997:Q1-2015:Q1)												
Horizon	**1**	**4**	**6**	**8**	**10**	**12**	**1**	**4**	**6**	**8**	**10**	**12**
	CPI						**Core CPI (CPI ex. Food & Energy)**					
Model 2 against Model 1												
Domestic slack	(a)						(b)					
IP-HP	1.012	1.027	1.064	1.089	1.101	1.118	0.982*	0.841**	0.824**	0.879*	1.023	1.279
GDP-HP	1.003	1.011	1.054	1.071	1.074	1.094	0.968**	0.801**	0.762**	0.865*	1.027	1.195
IP-FD	1.055	1.046	1.054	1.072	1.059	1.065	1.049	0.958*	0.871**	0.852**	0.882**	0.918*
GDP-FD	0.992	0.983	0.692	0.973	0.972	0.969	1.004	0.929**	0.834***	0.832***	0.869**	0.914**

TABLE A5

Note: This table reports the forecasting performance with an estimation sample covering 1984:Q1-1996:Q4 and a pseudo out-of-sample forecasting sample over 1997:Q1-2015:Q1. We distinguish domestic slack based on whether we use the one-sided Hodrick-Prescott (HP) filter or first-differencing (FD) for filtering the data. We construct alternative measures of domestic slack based on industrial production (IP) and real GDP (GDP) data. The entries in this table represent the MSFE of the forecasts under different versions of Model 2 where the economic predictor is domestic slack relative to the MSFE of the benchmark model (Model 1). Asterisks denote that the MSFE of a given variant of this modified Model 2 is statistically different and more accurate than the MSFE of the benchmark model at 1 (***), 5 (**), and 10 (*) percent significance levels.

The modification of Model 2 that relies on domestic slack as an economic predictor represents a conventional closed-economy Phillips-curve-based specification.

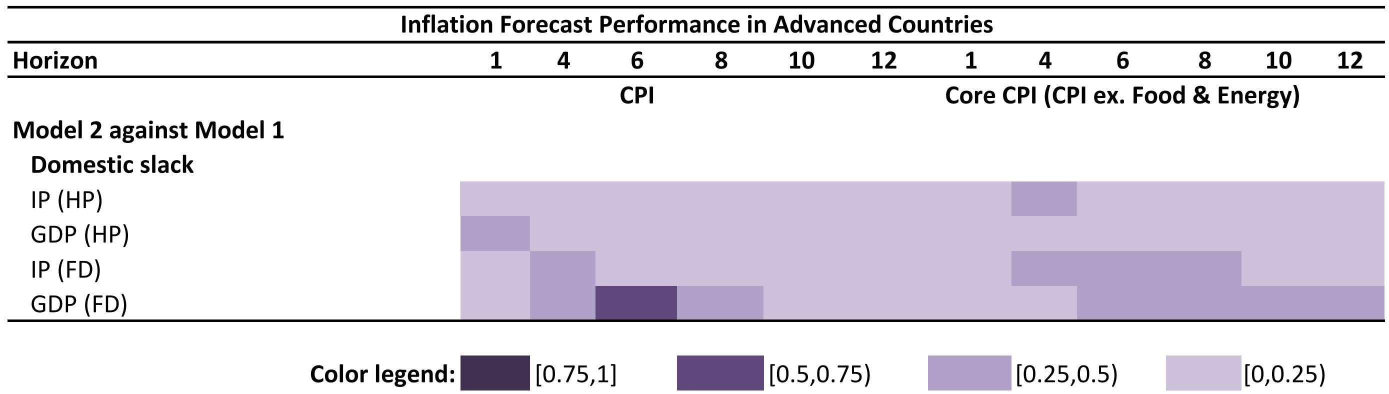

TABLE A6

Note: This table summarizes the forecasting performance for a sample of 14 countries which includes: Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and United States. The estimation sample covers the period 1984:Q1-1996:Q4 with a pseudo out-of-sample forecasting sample over 1997:Q1-2015:Q1. We distinguish domestic slack based on whether we use the one-sided Hodrick-Prescott (HP) filter or first-differencing (FD) for filtering the data. We construct alternative measures of domestic slack based on industrial production (IP) and real GDP (GDP) data. The entries in this table represent the fraction of countries out of the 14 for which we have data where we find that the MSFE of each forecasting model (a variant of Model 2 where the economic predictor is domestic slack) is statistically different and more accurate than the MSFE of the country's benchmark model (Model 1) at least at the 10 percent significance level. Specific country results are available from the authors upon request.
(*)The results for the contiguity measure are reported for 10 countries only (Australia, Japan, Sweden, and United Kingdom were omitted).
The modification of Model 2 that relies on domestic slack as an economic predictor represents a conventional closed-economy Phillips-curve-based specification.

Forecasts of U.S. Inflation - Relative MSFEs (1997:Q1-2015:Q1)												
Horizon	**1**	**4**	**6**	**8**	**10**	**12**	**1**	**4**	**6**	**8**	**10**	**12**
	CPI						**Core CPI (CPI ex. Food & Energy)**					
Model 4 against Model 1												
Global inflation	(a)						(b)					
Equal weights	0.598***	0.788***	0.825**	0.800**	0.743**	0.679**	0.911***	0.777**	0.755**	0.736**	0.685**	0.608**
Contiguity	0.982*	0.915*	0.838**	0.776**	0.696**	0.577***	0.977*	0.907*	0.869**	0.832**	0.783**	0.708**
Distance	0.762***	0.786***	0.728***	0.679***	0.636***	0.567***	0.964**	0.917**	0.881**	0.847**	0.813**	0.811**
Pop. weighted distance	0.961**	0.888**	0.809**	0.774**	0.662**	0.542***	0.972*	0.897**	0.856**	0.818**	0.766**	0.691**
Trade weights (1984-2014)	0.507***	0.773***	0.812**	0.771**	0.707**	0.626**	0.895***	0.785**	0.786**	0.776**	0.726**	0.656**

TABLE A7

Note: This table reports the forecasting performance with an estimation sample covering 1984:Q1-1996:Q4 and a pseudo out-of-sample forecasting sample over 1997:Q1-2015:Q1. The world countries used to construct global inflation include: Australia, Austria, Belgium, Canada, Chile, France, Germany, Italy, Mexico, Netherlands, Sweden, Switzerland, Japan, Korea, Spain, Taiwan, United Kingdom, and United States. The entries in this table represent the MSFE of the forecasts under each variant of Model 4 relative to the MSFE of the benchmark model (Model 1). Asterisks denote that the MSFE of each variant of Model 4 is statistically different and more accurate than the MSFE of the benchmark model at 1 (***), 5 (**), and 10 (*) percent significance levels.

Model 4 relies on global inflation alone as an economic predictor but is not consistent with theory.

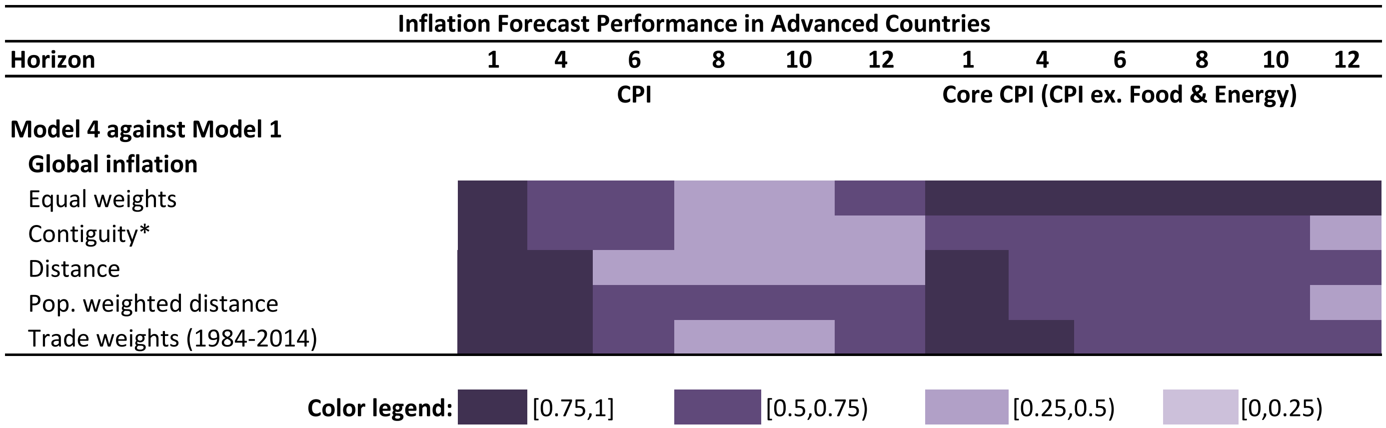

TABLE A8

Note: This table summarizes the forecasting performance for a sample of 14 countries which includes: Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and United States. The estimation sample covers the period 1984:Q1-1996:Q4 with a pseudo out-of-sample forecasting sample over 1997:Q1-2015:Q1. The world countries used to construct global inflation include: Australia, Austria, Belgium, Canada, Chile, France, Germany, Italy, Mexico, Netherlands, Sweden, Switzerland, Japan, Korea, Spain, Taiwan, United Kingdom, and United States. The entries in this table represent the fraction of countries out of the 14 for which we have data where we find that the MSFE of each forecasting model (a variant of Model 4) is statistically different and more accurate than the MSFE of the country's benchmark model (Model 1) at least at the 10 percent significance level. Specific country results are available from the authors upon request.
(*)The results for the contiguity measure are reported for 10 countries only (Australia, Japan, Sweden, and United Kingdom were omitted).
Model 4 relies on global inflation alone as an economic predictor but is not consistent with theory.

Relative in-sample predictive performance				
Horizon				
Model 3 against Model 4	**CPI**		**Core CPI (CPI ex. Food & Energy)**	
M3: Global inflation & Domestic slack (IP-HP)				
M4: Global inflation	**MSE3/MSE4**	**SIC3-SIC4**	**MSE3/MSE4**	**SIC3-SIC4**
Equal weights	[0.25,0.5)	[0,0.25)	[0.75,1]	[0,0.25)
Contiguity*	[0.25,0.5)	[0,0.25)	[0.75,1]	[0,0.25)
Distance	[0.25,0.5)	[0,0.25)	[0.75,1]	[0,0.25)
Pop. weighted distance	[0.25,0.5)	[0,0.25)	[0.75,1]	[0,0.25)
Trade weights (1984-2014)	[0.5,0.75)	[0,0.25)	[0.75,1]	[0,0.25)
M3: Global inflation & Domestic slack (GDP-HP)				
M4: Global inflation				
Equal weights	[0.5,0.75)	[0,0.25)	[0.75,1]	[0.25,0.5)
Contiguity*	[0.25,0.5)	[0,0.25)	[0.75,1]	[0.5,0.75)
Distance	[0.5,0.75)	[0,0.25)	[0.75,1]	[0.5,0.75)
Pop. weighted distance	[0.5,0.75)	[0,0.25)	[0.75,1]	[0.5,0.75)
Trade weights (1984-2014)	[0.5,0.75)	[0,0.25)	[0.75,1]	[0.25,0.5)
M3: Global inflation & Domestic slack (IP-FD)				
M4: Global inflation				
Equal weights	[0.5,0.75)	[0,0.25)	[0.25,0.5)	[0,0.25)
Contiguity*	[0.5,0.75)	[0,0.25)	[0.25,0.5)	[0,0.25)
Distance	[0.5,0.75)	[0,0.25)	[0.25,0.5)	[0,0.25)
Pop. weighted distance	[0.5,0.75)	[0,0.25)	[0.25,0.5)	[0,0.25)
Trade weights (1984-2014)	[0.25,0.5)	[0,0.25)	[0.25,0.5)	[0,0.25)
M3: Global inflation & Domestic slack (GDP-FD)				
M4: Global inflation				
Equal weights	[0.5,0.75)	[0,0.25)	[0.5,0.75)	[0,0.25)
Contiguity*	[0.5,0.75)	[0,0.25)	[0.75,1]	[0.75,1]
Distance	[0.5,0.75)	[0.25,0.5)	[0.5,0.75)	[0,0.25)
Pop. weighted distance	[0.5,0.75)	[0.25,0.5)	[0.5,0.75)	[0,0.25)
Trade weights (1984-2014)	[0.5,0.75)	[0,0.25)	[0.5,0.75)	[0,0.25)

Color legend: [0.75,1] [0.5,0.75) [0.25,0.5) [0,0.25)

TABLE A9

Note: This table summarizes the in-sample predictive performance of Model 3 relative to Model 4 for inflation in 14 advanced countries (Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and United States) over the 1984:Q1-2015:Q1 period. We distinguish domestic slack based on whether we use the one-sided Hodrick-Prescott (HP) filter or first-differencing (FD) for filtering the data. We construct alternative measures of slack based on industrial production (IP) and real GDP (GDP) data. We report the performance based on the relative mean squared errors (relative MSEs) and the differences of the Schwarz Information Criteria (SIC), respectively. To be more precise, we report the fraction of countries in the sample where Model 3 is favored over Model 4 based on relative MSEs and SIC differences, respectively. In particular, a relative MSE less than one or SIC difference less than zero tends to favor Model 3 over Model 4. Specific country results are available from the authors upon request.
(*)The results for the contiguity measure are reported for 10 countries only (Australia, Japan, Sweden, and United Kingdom were omitted).

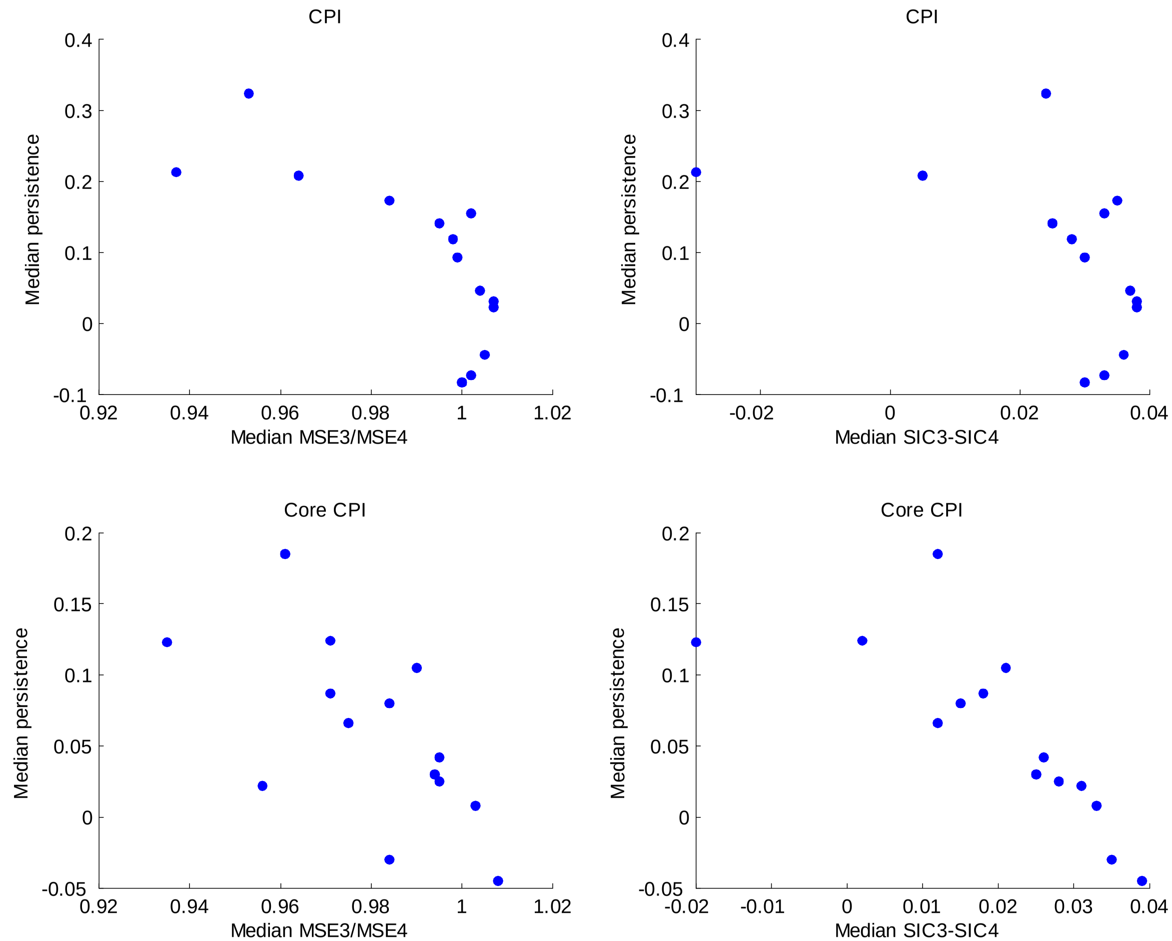

FIGURE A1

Note: This figure plots the persistence of the domestic output gap under Model 3 for each one of the 14 advanced countries in our sample against: (i) the relative MSEs of Model 3 over Model 4, and (ii) the SIC differences of Model 3 versus Model 4. Persistence is measured by the inverse of one minus the sum of the coefficient estimates (current and lagged) on the domestic output gap from Model 3. The median values for each country are calculated across all specifications considered also in Table A9.

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